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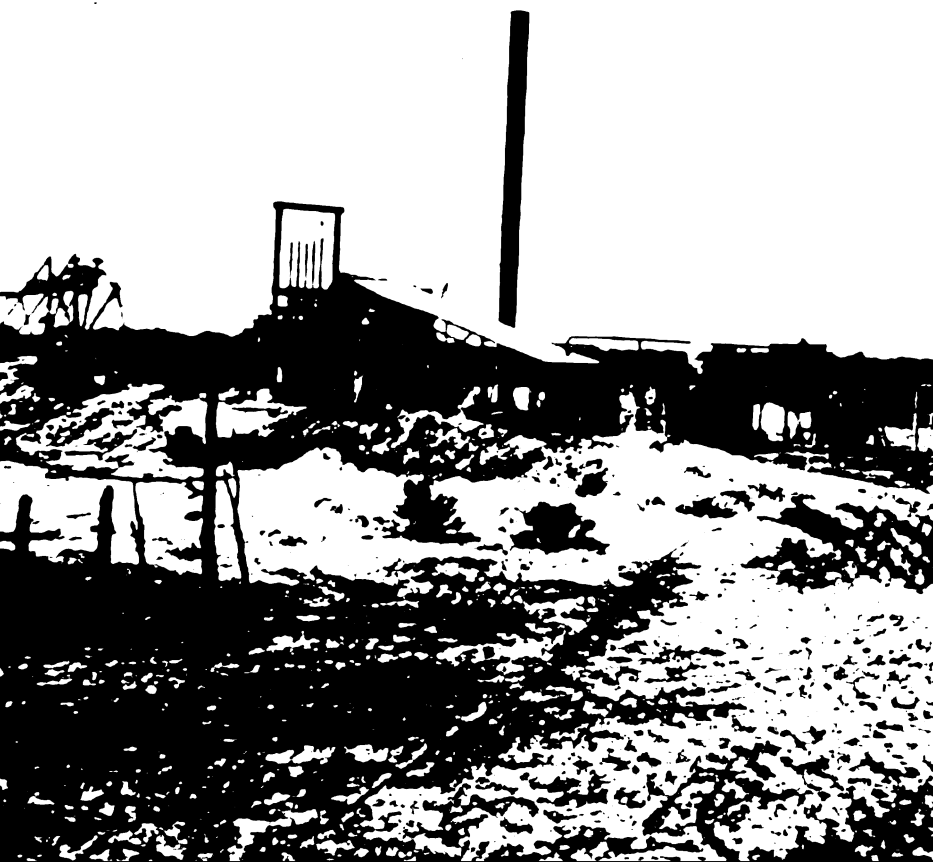
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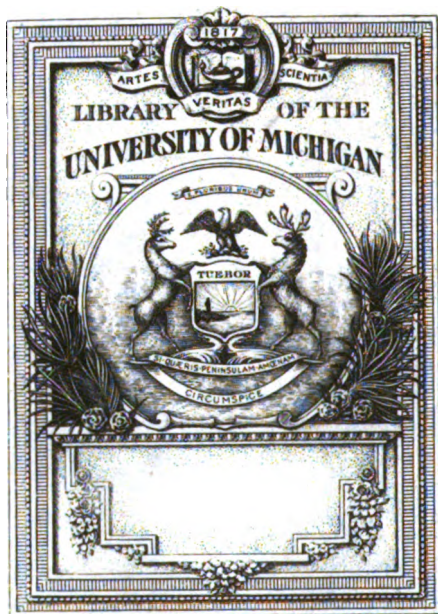
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# *Bulletin*

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1906.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 22.

THE  
AURIFEROUS DEPOSITS AND MINES  
OF  
MENZIES.

NORTH COOLGARDIE GOLDFIELD,

BY  
HARRY P. WOODWARD,  
*Assistant Government Geologist.*

*Issued under the authority of the Hon. H. Gregory, M.L.A.,  
Minister for Mines.*

WITH TWO MAPS AND SIX PLATES OF SECTIONS.



PERTH:

BY AUTHORITY: A. CURTIS, ACTING GOVERNMENT PRINTER.

1906.

# GEOLOGICAL MAPS AND REPORTS ISSUED BY GEOLOGICAL SURVEY OF WESTERN AUSTRALIA.

## I.—MAPS.

- Geological Map of Northampton: by A. Gibb Maitland. Scale, 10 chains per inch. Two sheets. Price, 2s. 6d. 1897
- Geological Map of the Collie Coalfield: by A. Gibb Maitland. Scale, 10 chains per inch. Price, 2s. 6d. 1897
- Geological Map of Coolgardie: by T. Battenfield and E. J. Allsopp. Scale, 10 chains per inch. Four sheets. Price, 12s. 6d. 1897
- Topographical Map of Menzies: by W. L. Campbell. Scale, 2 chains per inch. Two sheets. Price, 2s. 1897
- Geological Sketch Map of the country between Cue, Peak Hill, and Menzies from the latest official information. Price, 1s. 1900
- Topographical Map of Kalgoorlie: by W. D. Campbell and S. J. Beche. Scale, 10 chains per inch. Four Sheets. Price 5s. 1900
- Mining Map of the Boulder Belt: by W. D. Campbell. Scale, 4 chains per inch. Two sheets. Price 5s. 1900
- Geological Map of the North Lead, Kanowna: by Torrington Blatchford. Scale, 8 chains per inch. Price, 1s. 1901
- Geological Map of Kalgoorlie: by A. Gibb Maitland and W. D. Campbell. Scale, 10 chains per inch. Six sheets. Price, 21s. 1902
- Geological Map of the Boulder Belt and Sheet of Horizontal Sections: by A. Gibb Maitland and W. D. Campbell. Scale, 4 chains per inch. Three sheets. Price, 12s. 6d. 1903

### *In preparation :*

- Geological Sketch Map of Western Australia: by A. Gibb Maitland. Scale, 1/1,584,000. Four sheets.

## II.—REPORTS.

Reports by the Government Geologist in connection with the Water Supply of the Goldfields (price, 2s. 6d.), containing—

- (a.) Proposed Boring for Artesian Water on the Coolgardie and Kalgoorlie Goldfields.
- (b.) Possibility of obtaining a Supply of Artesian Water at Menzies.
- (c.) Cue Water Supply for Crushing Purposes. 1897.

### *Annual Reports :—*

1. Progress Report for the Year 1897. (*Out of print.*) 1898.
2. Progress Report for the Year 1898. Price, 1s. 1899.
3. Progress Report for the Year 1899. Price, 1s. 1900.
4. Progress Report for the Year 1900, containing—

Administrative Report; The Staff; Field Work; Principal Results of the Year's Field Operations; Kalgoorlie Goldfield; Phillips River Goldfield; Gold Finds on the Preston and Ferguson Rivers; The Present Condition and Future Prospects of the Greenbushes Tinfield; Boring for Coal near Albany; North Lead, Kanowna; Bulong Deep Leads; Coolgardie Deep Leads; Alluvial Deposits, Donnybrook Goldfield; Subsidy to the Norseman Gold Mines, Ltd.; Gascoyne District; Extension of Artesian Water-carrying Strata from South Australia; Laboratory Work; Office Accommodation. Price, 1s. 1901.

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# GEOLOGICAL SURVEY.

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## PREFATORY NOTE.

**T**HIS report upon the Auriferous Deposits and Mines of Menzies, by Mr. H. P. Woodward, forms another of the series designed to treat of the different mining centres of the State.

The geological work was based upon the topographical map prepared by Mr. W. D. Campbell in the year 1899. The existence of this map greatly facilitated Mr. Woodward's work, and it is much to be regretted that it has not hitherto been found possible to have the necessary topographical work completed and available before the geological surveys of important mining centres are undertaken. The preparation of the topographical map of Menzies involved a good deal of labour, necessitating the fixing of all shafts, etc., in addition to running contour lines 10 feet apart in altitude; the survey was carried out with a four-inch tacheometer, and as a check a few measurements were made with a chain. In order to preserve continuous contour lines, the survey was carried a little further than would otherwise have been the case.

The area embraced by Mr. Woodward's work covers about 50 square miles, and includes the productive area of the district so far as at present understood. The field work, upon which Mr. Woodward's geological and mining work is based, was commenced in May and concluded on the 20th of October, 1905, but owing to the necessity for him remaining in touch with the Perth office during my absence in the North-West, and in paying short visits to different portions of the State for specially urgent purposes, the Menzies survey could not be carried out continuously.

In its essential geological features, Menzies consists of a complex of basic rocks, through which have been intruded a series of acidic dykes, which in all probability emanated from the large granitic mass which forms the higher ground in the vicinity of Springfield, near the eastern border of the map.

The ubiquitous cover of superficial deposits has rendered geological mapping somewhat difficult, but so far as possible the different rock masses and associated ore deposits have been delineated on the geological map with such a degree of accuracy as the scale of the field plans would admit.

The basic crystalline rocks of Menzies are of considerable importance, as they are everywhere genetically connected with the

auriferous quartz reefs of the district; they consist for the most part of amphibolite and diorite, and their derivatives: serpentine, chlorite, and hornblende schists. Many of the more or less foliated or quasi-schistose basic rocks, when followed down to about 100 feet or so below the surface, gradually give place to massive greenstones, which, however, when exposed to the weather, rapidly become fissile and split readily along cleavages planes. This dormant foliation has been proved to exist to the greatest depths yet attained on the field, viz., 800 feet.

The acidic rocks only occupy a relatively small area of the surface in the vicinity of Springfield, though their existence beneath the superficial cover has been proved in wells and quarries to the north and west. They consist chiefly of gneiss, mica schist, sericite schist; and, as is the case with the basic rocks, the schistose character seems to be lost at a variable depth below the surface. There seem good reasons for believing that this mass consists of a porphyritic granite, which owes its present condition to crushing and hydration. A portion of the field is traversed by numerous acidic dykes, some of which are of considerable horizontal extent; they are generally represented by sericite schists and allied rocks, though transitions from such to porphyritic granite have been noticed.

The quartz reefs, which are confined to the greenstones, are of various types and of somewhat different characters. Several large banded quartz reefs, approaching quartzite in appearance, occur in certain localities; they are, however, of no extent, nor are they of any economic importance.

Some very ferruginous lodes which, below water-level often pass into marcasite, are met with, and can be traced for considerable distances; whilst these deposits have proved to be auriferous, they have invariably been found to be of so low a grade as to be unworkable.

Most of the gold from Menzies has been obtained from segregation reefs, which have an irregular lenticular habit. One of the longest of these is 1,600 feet, though with the exception of those in the few larger mines, these segregation reefs do not attain any great longitudinal extent, but form a series of small but rich parallel veins.

One or two fissure-veins occur in the field, but the comparative poverty of their gold contents is more than compensated for by their extent and the probabilities of continuity in depth.

Every available mine on the field was visited by Mr. Woodward during the course of his work, but many of the larger properties were shut down and inaccessible. Full and detailed descriptions of the mines, accompanied by mining plans, without which the text would be wellnigh unintelligible, are given *in extenso* in the report.

Statistics of the production of the district are attached to the descriptive portions, and in the form in which they are represented the figures give as complete a record of the gold yield of the various deposits of Menzies as is possible. These demonstrate that from the area embraced by the Geological Map of Menzies there have been produced 403,787·71 fine ounces of gold, derived from the milling of 348,967·40 tons of quartz, or at the rate of 1·15 fine ounces per ton.

The deposits so far opened up have not been, below the depth of 300 feet, as satisfactory in regard to both quantity and quality of the ore as in the higher levels. Although many of the larger ore deposits appear to have been virtually worked out, there seems every reason to believe that other deposits of a somewhat similar nature to the smaller veins already opened up in many of the old workings may be reasonably expected to be discovered by judicious exploration, and may prove possibly of equal value.

The report and accompanying maps were, on being submitted to the Hon. the Minister for Mines, ordered to be printed for public information.

The index to names, places, mines, reefs, etc., occurring in the report has been prepared by Mr. P. J. Atkins, Clerk to the Geological Survey.

A. GIBB MAITLAND,  
Government Geologist.

Geological Survey Office,  
Perth, 12th April, 1906.





# The Auriferous Deposits and Mines of Menzies,

## NORTH COOLGARDIE GOLDFIELD.

### Introduction.

This report is accompanied by a geological and topographical map of the district around the town of Menzies, also a plan showing the underground workings, lodes, cross-courses, etc., of the principal mines, and has been divided into sections under the following heads:—

- I. *General*.—A description of the position of the area under review, with its discovery, history, and annual production of gold from 1896 to 1905.
- II. *Topography*.—A short general description of the physical features of the district.
- III. *Water Supply*.—A description of the sources from which it is obtained, and its character, with a rainfall table for the preceding nine years.
- IV. *Descriptive Geology*.—A short description of the nature of the various rocks, dykes, reefs, and faults.
- V. *Economic Geology*.—A short description of the various mines, with the quantity of gold yielded by each lease in the district since its discovery.
- VI. *Conclusion*.

Appendix I.—Synoptical Table showing the yield of the Leases at Menzies up to the end of 1905.

Appendix II.—List of Rocks in the Geological Survey Museum, collected in the Menzies District.

### General.

Menzies is situated in the North Coolgardie Goldfield, longitude 121 degrees, S. lat. 29 degrees 40 minutes, at an altitude of 1,403 feet above the sea-level, being connected with Perth and Fremantle by a railway line 467 miles in length *via* Kalgoorlie.

In a Handbook of the North Coolgardie Goldfield, compiled by Mr. J. McIntyre and published by the *Herald*, at Menzies, in 1899, it is stated:—

“L. R. Menzies, after whom the district is named, and J. McDonald (representatives of a Perth syndicate) applied on the 1st

October, 1894, for the first lease in what is now known as the Menzies district. They were not, however, the first prospectors. A well-equipped party came from the 90-mile (Goongarrie) in August of that year, consisting of J. Brown, C. Kirby, and C. Jackman, and had, to a certain extent, developed a show about two miles south of the lease Messrs. Menzies and McDonald applied for. It did not turn out as expected, and the lease was not at that time applied for, though afterwards it was taken up and called the 'Pioneer' (Lady Harriet). The lease, however, which Menzies obtained was the world-famed 'Lady Shenton,' the leading mine of the district."

Owing to the richness of the early discoveries, this district rapidly attracted considerable attention in the mining world, with the result that numerous companies were floated and large areas applied for as leases. Unfortunately, however, the rich properties were limited, and, more unfortunately still, the lodes in these, after yielding a considerable quantity of gold, have, with a few exceptions, decreased so considerably in size and richness in their lower levels that work has been practically suspended.

Up to the end of the year 1905 over 400,000ozs. of gold were obtained from this district, of which total over seven-eighths were produced by seven Companies, the properties of five of which have now practically ceased to be productive. In spite of this fact it is most satisfactory to note that the gold returns from this district have not fallen off as considerably as might have been expected, this being due to the large number of small rich shows that have been developed by working miners since the establishment of a State Battery.

The following is a statement of the gold yield from this district, from its inception up to the end of 1905, as reported to the Mines Department:—

*Table showing the Annual Yield of Gold from the Menzies District.\**

Year.	Ozs. crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ounces.	ozs.
Prior to 1897 ... ..	8,472	17,135·24	2·02
1897 ... ..	26,181·35	45,979·54	1·75
1898 ... ..	24,114·00	45,691·80	1·89
1899 ... ..	38,283·05	50,076·01	1·30
1900 ... ..	34,064·75	39,720·09	1·16
1901 ... ..	38,202·25	43,831·80	1·14
1902 ... ..	43,945·50	47,080·63	1·07
1903 ... ..	51,782·35	47,929·20	·92
1904 ... ..	41,984·85	31,146·12	·74
1905 ... ..	41,935·30	35,197·28	·84
Total ... ..	348,967·40	403,787·71	1·15

\* This table includes only the returns from those leases which are embraced by the area of the Geological Map.

## **PART I.—General Geology.**

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### **Section I.—Topography.**

The area under review surrounds the township of Menzies, covering about 50 square miles, the survey of which was carried out by Mr. W. D. Campbell, Assoc.M.Inst.C.E., F.G.S., Topographical Surveyor, and now Assistant Geologist; and it is upon the plan which he prepared, and which was printed in 1899, that the present geological lines have been laid down.

The tract covered by the plan can best be described as an elevated hilly region surrounded by alluvial plains, which latter gradually fall towards lakes.

The whole was originally thickly covered with mulga scrub with here and there stunted gum trees, but since mining operations started the timber-cutters have made very considerable inroads into it, in fact those portions near the town and mines have been absolutely denuded of timber.

The highest hill is Mt. Misery, 1,660 feet above sea-level, or 330 feet above the alluvial flats; it is situated near the centre of a rough range of hills which run in a north-west direction upon the eastern side of the district. These hills present a steep face to the eastward but are flanked by a belt of broken elevated country to the westward, which gradually descends towards the flats which lie to the north, south, and west.

Except in the hilly regions, well-defined watercourses are of rare occurrence owing to the very gradual fall and the pervious nature of the surface; in consequence, after heavy rain, like thunderstorms, large tracts of the alluvial flats may often be covered for a short time by a thin sheet of water, whilst after light rains no water runs, but the whole becomes so boggy as to be impassable.

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### **Section II.—Water Supply.**

Owing to the facts mentioned above and the generally light and very uncertain character of the rainfall this area is not adapted to the conservation of surface water, whilst the subterranean supply is very limited; the area over which that of a potable quality can be obtained is small and the supply extremely limited.

Although the united supply from the above two sources has very frequently proved inadequate for the domestic requirements of the residents the demand for an extra supply is of too intermittent a character to warrant the erection of a condensing plant, there-

fore water is now hauled by the railway from the Goldfields Water Supply reservoir at Kalgoorlie, a distance of 80 miles, which materially increases the cost of living.

In the upper levels of the mines a small supply of salt water is often encountered in sinking but this is practically lost in depth, therefore milling plants, etc., are mainly dependent upon a supply of salt water pumped a considerable distance from a low-lying area to the westward of Menzies, which renders treatment costly and precludes the possibility of the profitable working of low-grade deposits. The underground fresh water supplies are confined mostly to alluvial basins upon the eastern side of the district, and being entirely dependent upon the rainfall the supply varies considerably and is limited.

*Annual Rainfall at Menzies.*

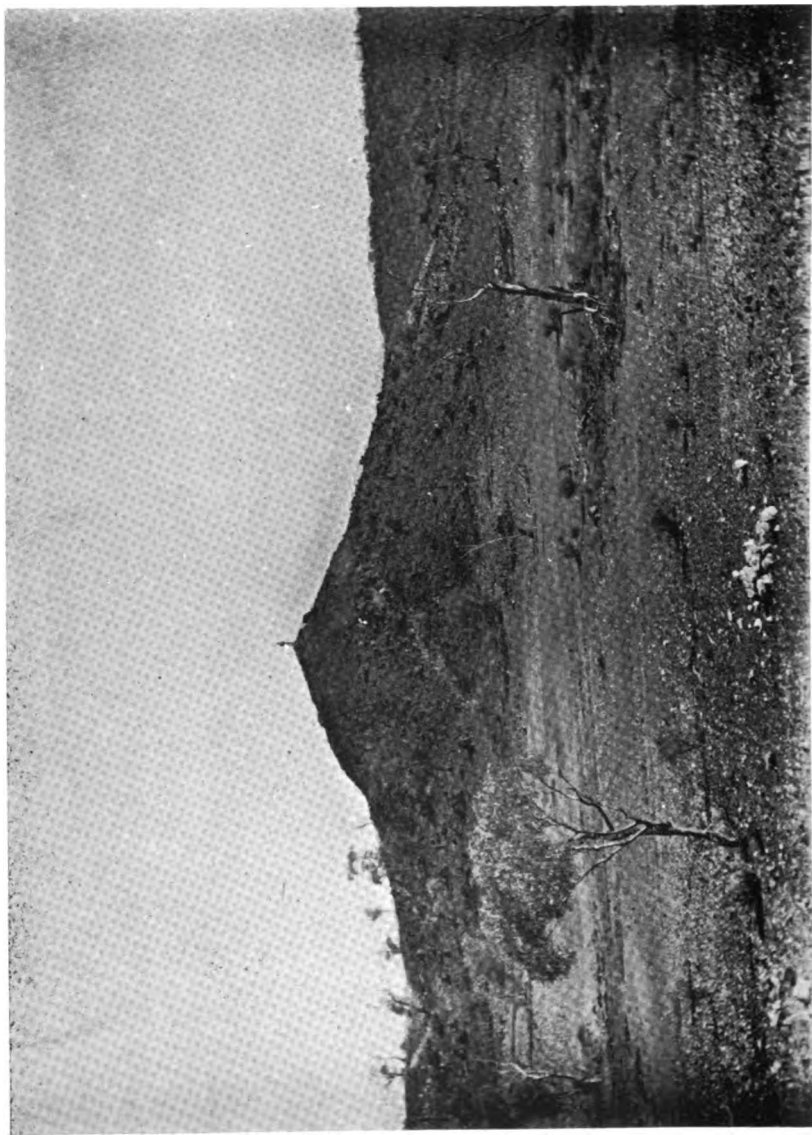
Year.	Inches.	Days upon which rain fell.
1897 ... ..	4.52	38
1898 ... ..	4.45	28
1899 ... ..	4.86	32
1900 ... ..	12.17	58
1901 ... ..	7.17	30
1902 ... ..	11.26	34
1903 ... ..	15.24	53
1904 ... ..	9.70	55
1905 ... ..	6.81	29

### Section III.—Descriptive Geology.

In order to follow this description it will be necessary to refer to the Geological Map of the district, upon which the boundaries of the various formations have been carefully laid down.

By reference to the Explanation of the Colours and Signs upon the map it will be seen that the rocks, which are represented by distinguishing colours and signs, have been classed under the following headings:—1st, the Recent, which is subdivided into Alluvium consisting of clay, loam, sand, and gravel of the flats and creek beds, and Laterites consisting of brown hematite (ironstone), ferruginous claystone, and conglomerate (cement) capping the hills and ridges. 2nd, the Crystalline and Altered Rocks, which have been subdivided into Basic consisting of serpentine and chloritic schists, amphibolites, aphanatic diorite, and other hornblende and allied rocks, and the Acid consisting of sericite, mica schist, granite, and quartzite. 3rd, the Igneous Rocks which occur as dykes of felsite, porphyry, and granite.





The two general cross-sections at the bottom of the map will make clear the fact that although a very considerable area is mapped as alluvium this is often of little thickness; in fact near the Lady Shenton mine and at several other points along the auriferous belt it barely covers the weathered schists, whilst reefs often outcrop through it. It is strictly speaking a superficial deposit resulting directly from the weathering of the schists *in situ*, but since it masks the underlying rocks, dykes, etc., and merges imperceptibly into the true alluvium, it has been included under that head.

In both sections the portions of the various rocks near the surface in the zone of hydration have been ruled to indicate their foliated nature, whilst the rocks beneath are coloured to represent diorite and granite respectively as their probable anhydrous character.

### Recent Superficial Deposits.

The greater portion of the surface of the area mapped is covered by shallow superficial deposits, which have been classed under two heads, viz.: Alluvium and Laterites.

The Alluvium covers all the plains, flats, and valleys, and consists of soil, clay, loam, sand, gravel, and cement (calcareous conglomerate), varying in thickness from a few inches to many feet, their surface being often covered with fragments of ironstone, quartz, or rock which when auriferous are worked as dryblowing patches and deep leads.

The term alluvium has been adopted to cover these recent surface accumulations as a matter of convenience, but it is hardly accurate nomenclature since only those portions which follow the drainage channels appear to have been deposited by the action of running water, whilst the balance, which is by far the most considerable, has evidently been formed from the gradual disintegration of the rocks by meteoric influences, but for obvious reasons it has been found impossible to distinguish it from the genuine alluvium.

The Laterites are found capping many of the hills and ridges, being apparently the remnants of an extensive formation which covered the entire western portion of the area, the softer portions of which have gradually yielded to atmospheric influences but still leave ample evidence of their previous existence in the ironstone fragments which cover the flats.

These cappings are composed of ironstone, which however varies very greatly in composition from almost pure limonite (hydrated oxide of iron or brown hematite) [1177-8, 1203-4, 6317] to earthy ochres and ferruginous clays.

These ironstones, although presenting a dark chocolate-coloured polished exterior, when broken are found to be of a very porous nature, which renders them very susceptible to atmospheric influences, with the result that the more or less horizontal hard crust has been riddled with pipes and caverns by meteoric water,



which, causing it to collapse from time to time, have so broken these cappings that they mostly present the appearance of an aggregate of rough masses.

Beneath these cappings are soft beds of a more or less earthy nature, which when followed down merge imperceptibly into the oxidised rock beneath; this portion of the formation is also a source of weakness to the ironstone, since animals and reptiles burrowing beneath the harder crust cause falls of the roof through leaving insufficient support.

Laterites are the result of subaerial decomposition of the rocks *in situ*, due to hydration and oxidation in a practically rainless and tropical country, consequently their composition is liable to vary considerably even over a small area, it being governed by the nature of the underlying rocks.

That ferruginous laterite cappings are most commonly met with is due to the fact that the amphibolite series from which they were derived are largely developed upon the goldfields and are rich in iron, whilst further deposits of this nature were able to resist recent denuding influences better than the softer deposits of a purely magnesian, calcareous, and aluminous character, and in consequence they not only remained themselves but also protected the underlying rocks, with the result that they now appear as ridges or hills since the adjoining unprotected country has been denuded. They are of little economic value upon this area, for, with the single exception of that upon the Crusoe hill a small but rich deposit of gold was discovered associated with one of these earthy ferruginous beds; in this deposit the gold was found to be of an entirely different character and of a much higher value than that obtained even from the oxidised zone in the mines, whilst subsequent trenching and cross-cutting beneath it failed to prove the presence of any auriferous body in the vicinity. The inference therefore is that this deposit results from the concentration of gold carried in small quantities in the country rock (this being a common feature of this belt), during which process the silver and baser metals were removed and the fine particles of gold united.

### The Crystalline Series.

These rocks not only outcrop over a considerable portion of this area but also underlie directly all the superficial deposits: great interest centres in them as they form the matrix of the auriferous quartz bodies.

They have been divided into two groups upon the map, viz.: (a) the Basic, which consists largely of hornblende and minerals resulting from its hydration, such as serpentine, talc, and chlorite; and (b) the acid, in which silica predominates.

The basic series are traversed by numerous felsite and granite dykes, which were apparently intruded prior to the formation of the quartz-veins since these latter intersect both the basic and acidic rocks, without the remotest partiality.





Of these rocks the basic cover by far the greater extent, presenting generally at the surface a schistose character [750, 752, 754, 1047] merging imperceptibly into massive crystalline amphibolites [801, 1174, 1192, 1968], which usually form rough ridges or bosses, but are clearly not dykes, since all attempts to define their boundaries failed utterly.

When these rocks are sunk upon, as in mining, their character quickly changes, the schistose structure giving place below the water-level (about 100 feet) to a massive aphanitic jointed diorite in which no cleavage planes are visible [6371, 6312, 6331]. It breaks in masses more or less cubical exhibiting absolutely no schistose structure to the naked eye, but on exposure to the action of the weather dormant cleavage planes rapidly develope, when it becomes fissile and splits in a shale-like manner when struck with a hammer. To what depth this dormant fissility actually extends it is impossible in the present condition of our knowledge to determine, but it is known to exist in a slight degree at the greatest depths attained at present in any of the mines, viz., about 800 feet vertical.

The schistosity within this area has a general strike to the north-westward, with an underlay of about 45 degrees to the westward; but in the Kensington belt the direction, for a distance of one mile, is found to have changed to the north-eastward, whilst the dip changes from north-west to south-east.

At the Goodenough, which lies about half a mile to the north of the northern end of the Kensington belt, a sudden change has taken place for a short distance, the cleavage planes striking east and west and dipping south.

The Acid group is only developed at the surface to any extent in one hill mass about two miles in length, which runs in a south-easterly direction from Jowett's Well, situated a little south of Mt. Misery; but they also have been proved to exist in wells and quarries beneath the alluvial flats to the eastward and northward [6330, 6318].

Where these rocks outcrop they generally consist of gneiss, mica schist, sericite schist, and quartzite [6321, 6365, 6320], but these characters are, as in the basic series, lost at a moderate depth below the surface, mica schist giving place to gneiss, and sericite schist to sericite slate; however, it is impossible to study what changes take place in these rocks below the water-level as they have not yet been sunk upon, but to judge from the changes that have taken place in the dyke rocks (as will be gone into later on) it is highly probable that this entire mass is an intrusion of porphyritic granite, altered near the surface by hydration and crushing.

At several points on the alluvial flats to the eastward of Mt. Misery, weathered schists are met with in the wheel-ruts or in trenches, whilst granitic rocks form the country at the Federal Group, which runs in a north-easterly direction, a little to the north-westward of the Kurrajong Lease, 3482. Along the railway line and the Niagara Road granite has been met with in sinking wells,

also in some quarries where weathered granite has been worked a little to the north-eastward of the town.

The basic rocks are intersected by numerous dykes, which are most largely developed at the surface along a belt which extends in a north-westerly direction from the north end of the outcrop of the acid rocks near Jowett's Well, passing the south end of the Kensington belt, and continuing to the northward of the water catchment area, gradually concentrating to the north-east corner of the town by the Hospital Reserve. A few scattered acidic dykes are also visible around Mt. Misery and at one or two other points upon this area; but although they do not outcrop along the auriferous belt owing to the alluvial covering, they are constantly met with in sinking. Such of the dykes as outcrop have been mapped with considerable care, under the supposition that they might have played an important part in the formation and enrichment of the reefs; this, however, upon careful examination of these bodies in the mines situated upon the auriferous belt, proved not to be the case, since it became evident at once that they were intruded prior to the deposition of the quartz veins, which are found to intersect them indiscriminately with the hornblende rocks.

The dykes where they outcrop generally present a felsitic and often silicious appearance, splitting into flags, which have been quarried for pitching purposes upon the northern side of the water reserve [6367-70], but at other points they have passed into very friable sericite schists. This latter characteristic is generally met with upon the auriferous belt immediately below the alluvium, but these, like the other rocks, rapidly change in depth.

No examination of these rocks could be made below the surface, except where mining operations have been carried on, but to judge from the general surface character they are apparently of one class, their different nature at the surface being due to local influences whilst metamorphism was taking place.

These dykes, where met with along the auriferous belt, as mentioned above, are generally represented by sericite schist, with here and there small patches of mica representing weathered granite. This character sometimes extends throughout the entire depth of the oxidised zone, or it may pass into weathered gneiss, thence into solid gneiss, or crushed granite, which at greater depths, when struck by bores, proves to be a porphyritic granite with small crystals of black mica [6340-4, 6337, 6364, 6371].

A complete series, illustrating this interesting transition from soft-weathered sericite schist into porphyritic granite, have been collected [6332-6].

At the north-west corner of this area two dykes of albite granite outcrop, which have been opened up evidently in the hope of their proving auriferous [6318].

The basic rocks also contain sparry veins of dolomite below the oxidised zone, whilst above it these are represented by creamy-





Photo., H. P. WOODWARD.

coloured veins of magnesian limestone [6322, 6315-6], which are particularly numerous amongst the serpentine schists. These rocks also contain veins of actinolite and a little inferior asbestos in places [6323, 6325].

### Quartz Veins.

The quartz reefs may be first divided into three classes, viz., auriferous, metalliferous, and barren reefs, of which the auriferous may be still further divided into (a) fissure veins and (b) irregular segregations forming composite lodes, and the barren into (c) irregular buck reefs and (d) fissure cross-courses.

Large barren buck reefs, which often approach a quartzite in character [785, 1189, 1202], having no definite course and of no considerable length of outcrop, are met with at several points upon this area; they are conspicuous, as they either form bold ridges or fragments and from their disintegration cover considerable areas of the surface.

The cross-courses are barren quartz bodies, formed along fault lines, which intersect the auriferous veins; they have a more or less east and west course and underlay mostly to the north, but are not as a rule of great longitudinal extent.

There are also a series of ferruginous lodes, which at the surface are oxidised, but near and below the water-level they pass into pyrites, mostly marcasite, containing a little gold, which, however, is in too small a quantity to cover the cost of working. These lodes have generally a more or less north-west course, and can often be traced for a considerable distance at the surface. One of these follows the main belt of dykes upon the north-east side, starting from a little east of Merry's Well, passing by the Maranora and Kensington mines to the south westward, and so on in a north-westerly direction for about a mile. Another large lode of this description is met with at the Goodenough mine, but here it does not appear to be of great extent.

Along the auriferous belt, bodies of this description are often met with and are generally known as mineral lodes. They are well-defined and apparently continuous for considerable distances, but are uniformly of very low grade. One very noticeable point with regard to these bodies is that they not only are of little value themselves, but are said as a rule to exercise an impoverishing effect upon the auriferous lodes at any points at which they come in contact.

Composite lodes.—The class of reefs around which the greatest interest centres are those from which the major portion of the gold produced from this district was obtained, and these may be classed as irregular lenticular segregation deposits. They occur either in the form of pipes or a series of lenticular masses; the longest axis, following the cleavage planes of the rock diagonally in a southerly direction, is called the shoot. In the upper levels it is not uncommon to find a series of such veins following parallel planes, but these gradually give out in depth. In the oxidised zone many of



these veins were very rich, the gold sometimes being associated with chloride of silver, whilst below the water-level galena is generally met with if the stone is of high grade. The greatest length to which one of these quartz bodies of the pipe-like form has continued to be payable is that worked in the Queensland Menzies mine; it is about 1,600 feet in length; whilst in the Lady Shenton, where the combined ore shoots have a much greater horizontal breadth, the shoots do not exceed 800 feet in length upon the incline; the vertical depth being in the former 660 feet and in the latter a little over 330 feet. With the exception of the few large mines, these veins are not usually of great extent individually, but more commonly consist of a series of small but rich quartz bodies, forming as a whole a lenticular mass, including the enriched decomposed rock called "formation"; but this latter diminishes the value of the stone too greatly to be profitably worked except by a plant upon the spot, therefore only the quartz is as a rule treated.

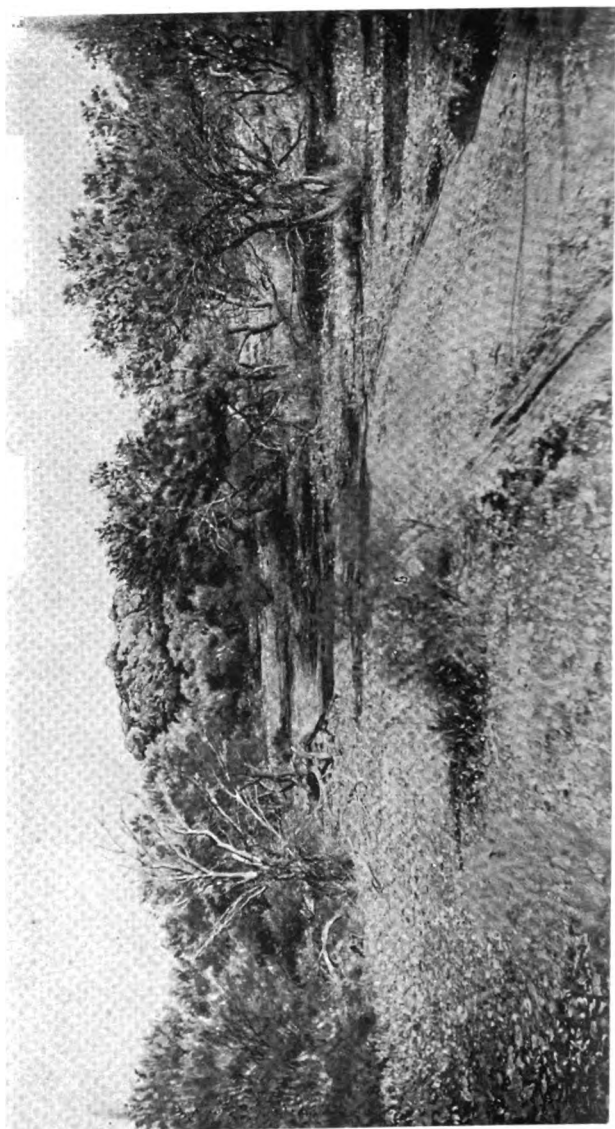
Lines of this nature are common throughout this belt, but since the surface is covered by superficial deposits a considerable amount of prospecting is often necessary before they are located. Owing to this, leases are repeatedly abandoned under the supposition that they are worked out, to be taken up later and worked again time after time as further prospecting by other parties revealed the existence of fresh quartz veins. Although other well-defined lenticular quartz bodies may be met with below the point at which the ore-shoot pinched out, it has been found that such bodies, if they do not come into existence either in the oxidised zone or immediately below it, have not been enriched to the extent which renders them payable, whilst the adjoining country rock at many points along this belt has proved to be auriferous.

Fissure-veins are not nearly so common in this district as the segregation veins, but a good example is exhibited in the Consolidated mine, the footwall of which is striated and highly fissile and indurated, indicating considerable movement. The Aspasia lode also shows the same indications. These lodes do not appear to carry so much galena as the segregation veins, neither are they so rich; but this is in a measure compensated for by their greater longitudinal extent of the ore-shoot, and also probable continuity in depth. The pay shoot in these reefs dips in the same direction as the others, viz., in a southerly direction, upon an inclined plane which dips at an angle of about 45 degrees to the south-westward, but they differ in so far that the vein does not of a necessity end at the point where the stone pinches out, but may be met with again further north or south along the fissure.

### Faults.

Besides the cross-head joint faults mentioned under cross-courses, which have disturbed the auriferous reefs by throwing them in an easterly or westerly direction, there are a series of faults





and thrust planes which coincide more or less with the foliation of the rocks, and in consequence are not apparent in the oxidised zone. These faults may form the fissures for lodes such as the Consolidated and Aspasia, where they more nearly coincide with the cleavage planes of the rock, or they may occur as thrust planes, when, although generally adopting the universal strike, they cut the foliation planes at a lower angle. These are possibly up-throw faults of limited extent, due to the intense lateral pressure caused by the expansion of the rocks whilst undergoing hydration, in which case they would have existed prior to the formation of the auriferous reefs, which latter sometimes terminate upon them.

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## **PART II.—Economic Geology.**

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### **Section I.—General.**

In the preparation of this section, which is devoted to a description of the reproductive ore bodies, great difficulties have been experienced owing to the fact that most of the large mines are now inaccessible, whilst, where accessible, timbered levels and worked out stopes (where not mullocked up) afford little information as to the character and size of the lode, since often a considerable quantity of the adjoining enriched rock has been removed with the stone, or the lode may have consisted of a number of small veins which necessitated the removal of the interpolated rock which was crushed or used for filling, according to its value.

To add to this difficulty, little reliable literature exists; whilst plans, in many instances, of underground workings of defunct Companies have been lost or taken away by the owners' representatives, and not lodged with the Government.

Information has therefore been collected from the most reliable sources, such as prospectors, mine managers, etc., who have most kindly done all in their power to assist in the investigations.

In order to give as clear an idea as possible of the nature of the ore deposits and the extent of the work done upon them, working plans, etc., have been reduced and reproduced upon a general map (Plate I.), which will be found of use if followed in conjunction with this section of the report.

, be constituted of lines of disconnected bodies or bunches,  
the latter of aggregates of pipes or lenses of quartz.



**Resurrection, G.M.L. 4859z.**—This lease is situated a few chains to the eastward of the last, the reef, which follows the same course, viz., east and west, has been opened up by a number of shallow underlay shafts upon the dip of the vein, which is to the south in decomposed schistose rock.

*Table showing the Yield of the Resurrection Reef.*

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
1897 ... ..	5'00	5'37	1'07
1898 ... ..	41'50	17'85	'43
Total ... ..	46'50	23'22	'50

The **European, G.M.L. 5210z**, and **Little Peter, G.M.L. 5201z**, are situated upon a small gravel rise near the Racecourse, about half-way between the St. Alban's and the town. Here some shallow holes have been sunk in the weathered rock, from which on the former 8 tons of stone were raised, which yielded 5'25ozs. of gold, and on the latter 10 tons, which yielded 3'41ozs. About a mile south of the last, at the north of the main belt and upon the north-western side of the town, are two properties now called the **Menzies Proprietary, G.M.L. 5236z**, and the **Dublin Castle, G.M.L. 5215z**, which were originally known as the **Little Gem, G.M.L. 3722z**, and **Selkirk, G.M.L. 2842z**, and owned by the **Menzies Gold Reefs Proprietary, Ltd.**, which Company did a considerable amount of prospecting upon them without discovering anything of sufficient size or value to be considered payable. These properties were both taken up by working miners in 1900, and, with the exception of time lost in changing hands, they have been worked ever since.

There are a large number of shallow shafts sunk upon small veins in the oxidised zone, with some driving and crosscutting, the rock being decomposed schist, and the reefs strike upon a north-westerly course and dip to the westward.

*Table showing the Yield of the Menzies Proprietary Reefs.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
					Ore crushed.	Gold therefrom.	
		tons.	ozs.	ozs.	tons.	ozs.	ozs.
1900 ...	Menzies Proprietary, G.M.L. 4953z	20'00	37'66	1'88			
1901 ...	Do. ...	70'25	53'22	'76			
1902 ...	Do. ...	39'00	71'81	1'84	129'25	163'69	1'35
1903 ...	Menzies Proprietary, G.M.L. 5140z	8'00	16'98	2'12			
1904 ...	Do. ...	183'00	120'11	'85			
1905 ...	Do. ...	10'00	8'63	'86	201'00	145'72	'72
1905 ...	Menzies Proprietary, G.M.L. 5236z	128'00	270'15	2'11	128'00	270'15	2'11
	Total ... ..	...	...	...	458'25	568'56	1'22

Table showing the Yield of the Dublin Castle Reefs.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average Rate per ton.
					Ore crushed.	Gold therefrom.	
1900	Dublin Castle, G.M.L. 4952z	tons. 38'00	oss. 49'36	oss. 1'30	tons.	oss.	oss.
1901	Do. ...	133'00	311'79	2'34			
1902	Do. ...	13'00	37'50	2'88			
1903	Do. ...	72'00	78'37	1'09			
1904	Do. ...	18'00	28'16	1'45	274'00	508'18	1'83
1905	Dublin Castle, G.M.L. 5215z	141'00	230'39	1'63	141'00	230'38	1'63
	Total ...	...	...	...	415'00	733'56	1'77

A little to the westward of the Dublin Castle are the following old leases, which have been held for short periods only; little work has been done upon them.

Table showing the Yield of the following Reefs.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	oss.	oss.
1899 ...	Menzies Main Reef, G.M.L. 4897z ...	39'00	15'98	'42
1903 ...	Easter Gift, G.M.L. 5095z ...	23'00	5'66	'24
1904 ...	Ophir, G.M.L. 5186z ...	17'00	5'92	'35
1904 ...	Witch Hazel, G.M.L. 5154z ...	21'00	8'82	'42
1904 ...	Ada Ella, G.M.L. 5185 ...	10'00	5'53	'55

**Victory North, G.M.L. 5068z.**—This lease lies to the south of the last-mentioned group and at the extreme north of the Aspasia or western line of lodes. Upon it a small body of stone, about eight inches wide, which follows the usual north-westerly strike and dip of 45 degrees west, has been opened upon at two points upon the eastern boundary. The northern group of workings consist of three shafts, two upon the underlay of the reef, which are connected, and a vertical shaft, which cut the reef at 150 feet, but which has not yet been connected with the other shafts.

Farther south there are two more shafts on the reef, which are connected at a shallow depth.

Table showing the Yield of the Victory North Reef.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	oss.	oss.
1902 ...	Victory North, G.M.L. 5068z ...	12'00	12'48	1'08
1903 ...	Do. " ...	51'00	109'88	2'15
1904 ...	Do. " ...	70'50	91'87	1'58
1905 ...	Do. " ...	39'00	60'50	1'55
	Total ...	172'50	274'63	1'59



**Victory, G.M.L. 5066z.**—This lease, which is situated immediately south of the last, was worked prior to 1901 by the Menzies Mining and Exploration Corporation as the Helena, G.M.L. 3203z, it was then taken up as the Surprise, G.M.L. 5002z, and in 1902 it became the Victory.

A good many shafts were sunk by the original Company in searching for the northern extension of the Aspasia lode, one being 30 feet; with a crosscut 100 feet both east and west in which a number of small veins were met with, whilst on the Surprise a shaft was sunk 43 feet on the western reef with a drive south 35 feet. The deepest shaft is 130 feet, of which 80 feet are vertical, it then follows a small reef with the usual strike but which dips at an angle of 65 degrees west. All the stone raised comes from the oxidised zone, and at the present time all work is confined to a vein upon the eastern boundary.

*Table showing the Yield of the Victory Reefs.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
					Ore crushed.	Gold therefrom.	
1901 ...	Surprise, G.M.L. 5002z	tons.	ozs.	ozs.	tons.	ozs.	ozs.
1902 ...	Do. " "	65'00	70 51	1'08			
1902 ...	Do. " "	58'00	45'73	'79	123'00	116'24	94
1902 ...	Victory, G.M.L. 5066z	20'00	32'52	1'63			
1903 ...	Do. " "	46'00	194'29	4'22			
1904 ...	Do. " "	93'00	162'21	1'74			
1905 ...	Do. " "	80'00	144'61	1'80	239'00	533'63	2'25
Total ...		...	...	...	362'00	649'87	1'79

**Menzies Lady Sherry, G.M.L. 2835z.**—This mine adjoins upon the south of the Dublin Castle and was first worked from 1896 until 1903 by the Menzies Lady Sherry G.M. Company, N.L., who also owned as block claims to the westward, leases Nos. 3806z and 3914z, both of which were named the Lady Sherry West; also 4069z, the lease then called Brown's. In 1903 the property was sold to the present owners, who now only hold G.M.L. 2835z.

Mr. H. Y. L. Brown says of this property in 1895—"Three quartz reefs were being mined upon here at the time of my visit. In No. 1 shaft I observed a quartz reef dipping westerly at an angle of 45 degrees with red mullocky formation, composed of white kaolin and quartz (decomposed granite). No. 2 shaft is on a quartz reef which dips westerly 45 degrees to 60 degrees. No. 3 shaft is also on a quartz reef which branches into veins below. The quartz contains coarse gold. The country rock in the neighbourhood of these mines is argillaceous talcose and chloritic schists, and decomposed diorite, and micaceous slate was observed in one place." [789.]

This lease has been worked at two points close to the south-west corner, the first being upon a reef which evidently outcropped and was probably the one referred to in Mr. Brown's report as occurring in shafts Nos. 1 and 2.

This reef has been worked to a depth of 107 feet 9 inches by an underlay and vertical shaft; it was not a continuous quartz body, but consisted of broken masses or small lenticular veins. From the bottom level a winze has been sunk 50 feet but no stone was met with. In these workings a faulting cross-course was met with at the bottom of the vertical shaft B, and also in the level at the bottom of the underlay shaft A, its course being a little north of west, with a dip to the northward; it is evidently the same body as is exposed upon the surface to the southward of these workings and between them and the main shaft, having a course nearly east and west. In the other workings, which lie 130 feet to the south-west, a vertical main shaft has been sunk to a depth of 260 feet, a small supply of salt-water being struck at 180 feet. From this shaft a series of small pipe-like lenticular quartz bodies have been worked to a depth of 150 feet, below which no ore has been discovered.

So far as the known ore bodies in this mine are concerned they have no apparent extension downwards below the existing workings, whilst even at the lower levels the veins have either cut out or become exceedingly small and poor; there is, however, a considerable area of untested ground between the existing workings and the Dublin Castle in which other rich veins may exist.

*Table showing the Yield of the Lady Sherry Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
					Ore crushed.	Gold therefrom.	
		tons.	ozs.	ozs.	tons.	ozs.	ozs.
1897	Menzies Lady Sherry, G.M.L. 3914z	299'00	484'32	1'52			
1898	Do. ....	449'00	383'20	'85			
1899	Do. ....	232'00	378'21	1'62			
1900	Do. ....	131'00	103'36	'78			
1901	Do. ....	683'00	735'79	1'08			
1902	Do. ....	414'00	243'08	'58			
1903	Do. ....	13'25			2,208'00	2,341'21	1'06
1903	Lady Sherry Leases, G.M.L. 3914z	221'00	286'26	1'29			
1904	Do. ....	392'25	259'86	'66			
1905	Do. ....	291'00	198'53	'68	904'25	744'65	'82
	Total				3,112'25	3,085'86	'99

**Aspasia and Pandora, G.M.Ls. Nos. 3100z, 3138z.**—These leases, which are the property of the Menzies Mining and Exploration Corporation, Ltd., are situated immediately south of the Victory and to the westward of the Lady Sherry, upon them a well-defined reef, which outcrops upon a north-west course with a dip to the south-westward of 53 degrees at the south end and 70 degrees at the north end, has been opened at the surface for a length of 370 feet by a number of underlay shafts. These shafts connect with the No. 1 or 56-foot level, which has been driven for a length of 520 feet, of which 440 feet was in payable stone.

The No. 2, or 117-foot level, has been driven for a distance of 320 feet, the north end to the limit of the pay shoot, whilst the south end was discontinued before that end was reached. The No. 3, or 160-foot level, which is 450 feet in length, has been driven from one end to the other of the ore body, and between it and the surface practically all the ore has been stoped.

A main vertical shaft has been sunk, which has been connected with this level by a crosscut, and also with the No. 4, or 237-foot level, which has been driven for a distance of 300 feet in a well-defined body of stone, that in the south drive, which is 180 feet long, is richer than the northern, but the latter is improving in the face.

From the No. 1 level a crosscut has been driven 100 feet east and 110 feet west, but no other lode of any value was cut.

The outcrop of this lode can be traced throughout the entire length of these two leases, and it is probably the northern extension of one of the reefs worked upon the Aurelia which lies to the southward. The lode is generally rather small in size, varying from 18 inches to 3 feet, but is well defined with a polished and striated footwall, which indicates that it is of the "true or fissure" type, the quartz having been deposited upon the wall of a fault, and in consequence the fissure is probably of considerable extent.

Upon this field veins of this type are not usually so rich as those of the segregation type, but are simpler deposits to handle owing to the fact that, although the quartz may pinch out, the fissure still remains as a guide or leader to further ore bodies. The individual ore chutes are usually of greater length, and so far their limit in depth has not been proved.

Upon this lease a large number of small shafts have been sunk upon small parallel ore bodies, but as yet sufficient work has not been done upon them to determine their character.

In sinking the main shaft, a small supply of salt water was struck at a depth of 144 feet from the surface, but the supply is too small to be of any value.

Since the gold returns from these leases are included in the Company's total, the actual amount yielded has been kindly furnished by the manager.

*Total Gold Yield to date.*

Ore crushed.	Gold therefrom.	Rate per ton.
tons.	ozs.	ozs.
6,213'00	8,407'00	1'35

**The Victory South, G.M.L. 5094z.**—This lease is situated immediately to the eastward of the Pandora, and upon it a

small shoot of stone has been followed down into the last-mentioned lease.

*Table showing the Yield from the Victory South Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1904 ...	Victory South, G.M.L. 5094z ...	243'00	166'50	'68
1905 ...	Do. " ...	44'00	145'31	3'30
	Total ...	287'00	311'81	1'08

The *Etrenna* and *Aurelia*, G.M.Ls. 4965z and 4966z.—These leases are a portion of what was originally the Menzies Gold Estates, Ltd., which Company worked them up to the year 1899. In 1900 and 1901 the returns are given under the title of *Etrenna* and *Aurelia* leases, after which date they became the property of the Menzies Mining and Exploration Corporation, Ltd., and in consequence the returns have been bulked, but the manager has kindly supplied the figures with regard to the leases.

The *Etrenna* lease is a portion of what was originally the *Crusoe West*, G.M.L. 3054z, and upon it a vertical working shaft has been sunk to a depth of 600 feet in extremely hard aphanitic diorite [6331], with the object of cutting the dip of the *Crusoe* reefs at 504 feet and 624 feet. As, however, no lode indications were met with, this work was abandoned (Plate II.). Later developments in the *Crusoe* prove that the vein did not extend into this lease. Upon the *Aurelia*, which was formerly called *Wilson's*, G.M.L. 3046z, three parallel lines of reefs have been worked to a vertical depth of from 80 to 110 feet, below which they decrease both in size and value. The eastern reef has apparently a very long outcrop, and if the working upon the *Ishtar*, G.M.L. 4976z, which lies to the south, are upon the same line, it gives a total length of 300 feet. The outcrop of this reef has been opened upon on this lease for a length of 450 feet, and driven on at the 63-foot level for a distance of 200 feet, and at the 95-foot level for 90-feet. It is a well-defined reef but of low value, 15dwts. being about the highest, the gold being worth little over £3 10s. per ounce.

The central reef has been driven on at the 56-foot level for a distance of 350 feet, and at the 87-foot level for 30 feet, the ore chute giving out at the bottom.

The western reef has been worked for a length of 350 feet at the 65-foot level and for 160 at the 112-foot level, beneath which the stone was valueless.

These reefs have only been worked in the oxidised zone, but, so far as can be judged, they are of the fissure type. If this should prove to be the case they would be worthy of further development in order to prove whether or not the veins increase in size and value

in the solid country, as 110 feet vertical depth is no criterion as to what these lodes may possibly be at a depth.

*Table showing the Yield of the Aurelia Reefs.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
					Ore crushed.	Gold therefrom.	
1897 ...	Menzies Gold Estates, Ltd., G.M.Ls. 3042z, 3046z, and 3054z	tons. 400'00	ozs. 131'22	ozs. '33	tons.	ozs.	ozs.
1898 ...	Do. ...	31'00	18'68	'60	431'00	149'90	'35
1899 ...	Do. ...	...	...	...	...	...	...
1900 ...	Etrenna and Aurelia, G.M.Ls. 4965z and 4966z	123'25	110'07	'89	...	...	...
1901 ...	Do. ...	101'00	111'17	1'10	224'25	221'24	'98
1902-5	Menzies Mining and Exploration Corporation, G.M.L. 4966z	687'75	618'46				
	Total ...	...	...	...	1,334'03	989'60	'74

The **Ishtar**, G.M.L. 4976z, is a portion of what was originally one of the Crusoe block claims, No. 3148z, and if it yielded any gold under former ownership, the record has been bulked and lost. The lease is now the property of the Menzies Mining and Exploration Corporation, Ltd., whose crushing returns are furnished by the manager. Seven shafts have been sunk upon what appears to be the continuation to the southward of the Aurelia reef, but although about 500 feet of driving has been done, no payable lode has been cut.

The **Aurelia West**, G.M.L. 5011z, is the property of the Menzies Mining and Exploration Corporation, Ltd., and is situated immediately to the westward of the Aurelia.

A shaft has been sunk to a depth of 76 feet, and a crosscut driven 200 feet east and west; in this latter a small vein of stone was cut 30 feet west of the shaft, from which a crushing was taken; at the west end, 90 feet from the shaft, an altered dyke was passed through. Fifty-six tons of stone crushed from this lease yielded 86'95ozs. of fine gold.

The **Maori**, G.M.L. 5196z., is situated within the township boundaries at the northern side, and covered a portion of the Government Reserve, upon which are the Warden's Court and Police Station.

These leases were originally held by the Maori Gold Mines. Ltd., in 1896 and 1897, which Company had one of the first batteries at work upon the field. All the developments were confined to one lease, No. 3059z, the principal portion of which was re-pegged

in 1898 and taken up as the Union Jack, G.M.L. 4889z; in 1901 it changed hands, and became the Maori, G.M.L. 4983z; whilst in 1904, with the name retained, it became G.M.L. 5196z.

A considerable amount of work has been done, but the only information obtainable was that a vertical shaft had been sunk to a depth of 280 feet without striking water.

*Table showing the Yield of the Maori Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
					Ore crushed.	Gold therefrom.	
1896	Maori G.M., Ltd., G.M.L. 3059z	tons 466·00	ozs. 560·50	ozs. 1·13	tons	ozs.	ozs.
1897	Do.	75·00	93·56	1·04	571·00	654·06	1·11
1898	Union Jack, G.M.L. 4889z	80·00	107·07	1·33			
1899	Do.	281·00	351·24	1·23			
1900	Do.	232·00	290·79	·95	593·00	679·10	1·16
1901	Maori, G.M.L. 4983z	04·00	29·45	·46			
1902	Do.		51·27	...	64·00	80·72	1·26
1903	Do.			...			
1904	Do. 5196z	12·00	2·63	·22	12·00	2·63	·22
	Total	...	...	...	1,240·00	1,416·51	1·14

The Freeman, G.M.L. 5039z, is a portion of the original Maori, and lies immediately south of the main workings upon what is now the Railway Reserve, therefore all the old shafts have been filled in. From this lease 3,000 tons of stone were crushed which yielded 20·75ozs. of fine gold.

The Menzies United was the name by which G.M.L. 3345z situated within and upon the south side of the town, was known. In 1902 it was taken up as the Horseshoe, G.M.L. 5045z, and in 1904 as the Menzies Horseshoe, G.M.L. 5145z; it is now abandoned.

*Table showing the Yield of the Horseshoe Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
					Ore crushed.	Gold therefrom.	
1896	Menzies United, G.M.L. 3345z	tons 12·00	ozs. 3·21	ozs. ·26	tons ...	ozs. ...	ozs. ...
1899	Do.	127·00	92·88	·73	139·00	96·09	·69
1902	Horseshoe, G.M.L. 5045z	43·00	13·74	·31	43·00	13·74	·31
1904	Menzies Horseshoe, G.M.L. 5145z	62·50	19·02	·30	62·00	19·02	·30
	Total	...	...	...	244·00	128·85	·52

The Crusoe Gold Claims, Ltd., own four leases, viz., Crusoe, G.M.L. 2823z; Robinson Crusoe East, G.M.L. Naida, G.M.L. 5017z; and Friday, G.M.L. 5018z. constituted, it is an amalgamation of the Menzies Crusoe Claims, Ltd., and the Menzies Gold Reefs Proprietary, Ltd.

The Crusoe mine is situated upon lease 2,623z., and roughly, of three groups of workings, besides a large quarry which a considerable quantity of auriferous gravel was in the laterite capped hill upon which the battery stands. The groups of workings may be classed as follows:—First, the original and dislocated extension of the Queensland Menzies lode outcrops at the south-west corner of lease 3009z, and under the south-east corner of 2823z and the Queensland Menzies lode; second, the central group which is situated about midway between the other two groups at the centre of the southern portion of 2823z; third, the main group lies in the centre and extends to the north-east corner of the same lease.

In 1895, Mr. H. Y. L. Brown says: "The lode forming this mine is a quartz reef associated with quartz and iron veins in a white kaolin rock apparently a decomposed felsite, is of considerable width in places, but irregularly defined; specimens of gold are found in the formation generally." \*

First. A considerable amount of work has been done upon the outcrop of the Queensland Menzies shoot, but the line of reef has apparently been dislocated by cross courses. A deep shaft has been sunk and a considerable amount of crosscutting done to the northward of this break, but no indications of the continuation of the reef could be obtained. No. 3 shaft is an underlay in the corner of lease 3009z, and appears to have been sunk on a portion of the Queensland Menzies outcrop, which was worked to a depth of 340 feet; all the other workings in this locality are inaccessible; there are apparently no plans other than of No. 3 shaft.

Second. Here three shafts have been sunk upon a reef which runs in a north-westerly direction, and dip to the south-west. In the northern shaft B, a winze has been carried down 155 feet to a pipe of ore which dips south. A cross vein which strikes east and west and underlays north passes through these workings, which are not now accessible.

The main workings (Plate II.) lie about 270 feet to the west of the last; the reef, which has a course of from north to east of north, has been worked by a main vertical shaft 340 feet deep and a series of underlay shafts and winzes.

There were three shoots of ore in this mine; the first northern shoot was small and only about 40 feet in width, the

\* Loc. cit., p. 4.

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*A. Gitt Maitland  
Government Geologist.*

*R. H. Irons del.*

*H. J. Pether, Government Lithographer, Perth, W. A.*



port of the main ore-shoot.



\* *Loc. cit.*, p. 4.

out at the 60 feet level. The second and third shoots were worked as one continuous ore body of 280 feet in length from the surface down to the 60 feet level, below which, however, the northern portion pipes off decreasing in size to 80 feet at the 156 feet level, and dying out about half-way between this level and the 235 feet level. The southern shoot which was the largest and longest in the mine was 170 feet wide at the 80 feet level, 130 feet at the 235 feet level, but below this it suddenly closed in to 50 feet in width, which gradually diminished until it died out altogether, a little below the 333 feet level. The sudden decrease in size is apparently due to the fact that a thrust plane makes its appearance coming in diagonally from the footwall, this may, if the dislocation took place after the formation of the reef, have severed a portion of the shoot below the 235 feet level. Indications rather point, however, to the prior existence of this thrust plane, in which case the reef fissure will be found to terminate upon it; this question could have readily been determined by an examination of the quartz at its contact with the fault at the time the stone was being worked.

The quartz veins in this mine have no polished walls or casing, the stone adhering firmly to the rock in the hard ground, whilst no line of fissure is met with after the stone has ceased to exist, therefore clearly pointing to their origin by segregation, and not by the upflow of magmatic solutions. That no continuation of the ore channel exists in depth has been clearly proved in the adjoining property, where the Menzies Gold Estates, Ltd., sunk a deep shaft with the object of cutting this lode. Nothing, however, but very solid rock was met with. There is no water in these workings, whilst the country is fairly soft to the 235 feet level [6322, 6323, 6325, and 6326].

To the northward of these workings a small quartz body, with a north-easterly course, has been worked to a depth of 144 feet, but it has apparently no continuity.

Whilst doing some work in connection with the battery, which is situated upon a low ironstone hill at the south-east corner of the lease, a deposit of auriferous gravel was met with, the gold in which was of a much higher value than that obtained from the reefs. A number of small shafts were sunk, and a considerable amount of crosscutting and trenching done with the object of locating the source from which this gold was derived. Since, however, no reef or leader was met with it is evident that this deposit is merely a surface accumulation resulting directly from the weathering of the rocks themselves, which often carry gold in small quantities along this belt.

All the known ore-shoots upon this mine are practically worked out, but as there is a considerable area of ground still unprospected other veins may yet be discovered upon the property, whilst cross-cutting below the 235 level may possibly reveal a dislocation of a portion of the main ore-shoot.

Table showing the Yield of the Crusoe Reefs.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.	
					Ore crushed.	Gold.
1896 ...	Menzies Crusoe Gold Claims. Ltd., G.M.L. 2823z	tons. 3,244·00	ozs. 6,226·42	ozs. 1 91	tons.	
1897 ...	Do. ....	4,199·00	5,631·23	1 34		
1898 ...	Do. ....	2,287·00	3,744·09	1 64		
1899 ...	Do. ....	6,077·00	6,399·21	1 05		
1900 ...	Do. ....	946·00	611·72	0 64		
1901 ...	Do. ....	1,726·00	1,319·58	0 65	18,479·00	23,93
1902 ...	Crusoe Gold Claims, Ltd., G.M.L. 2823z	675·00	720·30	1 07		
1903 ...	Do. ....	1,562·00	1,005·79	0 64		
1904 ...	Do. ....	6,005·00	2,818·84	0 47		
1905 ...	Do. ....	3,533·00	1,417·93	0 40	11,775·00	5,96
Total ...					30,254·00	29,88

**Queensland Menzies Gold Mining Co., N.L.**—This property consisting of two leases, the Wedderburn, G.M.L. 4969z, and the Oceanic, G.M.L. 4969z, is situated upon the main belt, the Oceanic being within the town of Menzies, Wedderburn immediately west of it and south of the Crusoe Reef.

The Queensland Menzies mine is upon the Wedderburn whilst the Oceanic, from which a small amount of gold was previously obtained, was taken up as a block claim in 1895, at which time very little work was done until recently, when a crosscut was started with the object of testing the lease for gold.

The Wedderburn was taken up in 1895, in which year Y. L. Brown says of it in his report:—"This is a quartz reef in which coarse gold is visible, striking N.N.W."\* It has been continuously worked ever since, and has been one of the most productive mines in the Menzies district.

The outcrop of the reef was discovered at the north-east corner of the lease, and was traced in the south-west to the Oceanic, G.M.L. 3009z, the entire length being something over 500 feet.

The developments upon this mine, until quite recently, consisted entirely of working shafts, levels, and winzes in the ore body, and crosscuts from the shafts to the levels; when, however, it gave signs of pinching out, at the instance of Dr. Jack, who was called in to advise the owners, a certain amount of prospecting, driving and crosscutting was undertaken.

A main vertical working shaft has been sunk to a depth of 540 feet, and an old main shaft 240 feet, an old water shaft 100 feet, and an underlay shaft 80 feet (Plate III.). Eight levels have been driven at 60 feet, 90 feet, 183 feet, 230 feet, 300 feet, 340 feet, 446 feet, and 534 feet respectively, vertical depth from the surface.

\* Loc. cit., p. 4.

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Hon. H. Gregory, M.L.A.  
Minister for Mines.

**MINERAL SECTION**  
OF THE

**JURN G.M.L.** 2836<sup>2</sup> REG<sup>2</sup> N°  
1435 POST „  
**AND MENZIES G.M.C.**  
**DOLGARDIE G.F.**

Scale of Feet

100 200

Stepped.....

*Bound*

is attained, then gradually diminish again. In consequence

LOC. CIT., p. 2.

the total length of which, inclusive of crosscuts, is about 3,000 feet. From a crosscut at the No. 8 level the lode has been followed down for a further distance of 210 feet on the dip to near the boundary of the adjoining property, the bottom of which is 617 feet vertical depth below the surface.

A small supply of salt water averaging about 100 gallons a day was cut at 150 feet below the surface beneath which a zone of about 50 feet of saturation was passed through, then hard impervious rocks were encountered.

The rocks which enclose the ore bodies may be divided into three zones, first, from the surface downwards about 100 feet may be called the oxidised zone in which the rocks gradually pass from yellow greasy clays into weathered schists of an argillaceous and chloritic nature; in the second, which may be called the zone of hydration, rocks of a more compact nature are met with, such as serpentine and hornblende schists; whilst in the third, or sulphide zone, which starts below the water-charged rocks an extremely hard aphanitic diorite is encountered, this rock, although presenting no foliation, has a distinct cleavage which is identical with the foliation of the schists; this although not always apparent very quickly develops upon exposure to the atmosphere, whilst the dormant and accompanying cross heads are taken advantage of in breaking ground [6311, 6312, and 6324].

The schists have a defined and very uniform foliation, the planes striking 20 degrees west of north and underlaying at an angle of about 45 degrees to the south-westward, whilst the ore chutes lie upon and cross these planes diagonally dipping at an angle of 35 degrees on a course of 15 degrees west of south.

The ore body in this mine although presenting the appearance of one continuous lode in the oxidised zone composed of quartz and formation on approaching the more solid country rapidly formed into a number of pipe like veins, the largest of which received distinctive names such as the western, eastern and hanging wall veins. The breadth of these combined ore bodies decreases rapidly with depth, starting with 500 feet (inclusive of the Crusoe) near the surface they become reduced to 150 feet at the 446 feet level, whilst the total width at the bottom of the winze, the lowest portion of the mine, does not exceed 20 feet. This is not only due to the diminution in size of the individual veins, but more particularly to the fact that they gradually die out one after the other until at the bottom only one remains and that very emaciated.

The ore-shoot in this mine has an exceptional length for a vein of this character in this district, it being 1,125 feet on the dip from the surface to the present bottom.

The individual quartz bodies vary very greatly in size, being of a lenticular pipe-like form; they start from nothing, gradually expanding until their maximum thickness, which may be many feet, is attained, then gradually diminish again. In consequence, it is

impossible to state what is the average size of the stone, but if the area of the stoped ground is taken, and the stone crushed cubed back into the solid, it gives an average of something like two feet of stone, which has averaged over  $1\frac{1}{2}$  ozs. of fine gold per ton.

These veins have no walls, in the accepted mining sense, the quartz being attached to the enclosing rock, whilst small strings of quartz often penetrate it for a considerable distance. The solid diorite rock in the immediate vicinity of the veins often carries gold in appreciable quantities, specimens having occasionally been met with in which coarse particles of gold were visible without the aid of a glass.

The enclosing fissures present all the appearance of shrinkage contortion cracks, having no continuity in depth nor length, and, although a number of them may occur in a group, or even upon the same planes of foliation, no connection whatever exists between them; they are therefore clearly segregation veins, the mineral matter, including the gold, having been infilled by percolation, either vertical, lateral, or both.

The group of veins worked in this mine lie at a point where a slight change in the course of the foliation has taken place; therefore the formation of the fissures may be due to the crumpling or buckling of the rocks after the release by thrusts of the lateral pressure, which caused their elongation or stretching. The quartz in the sulphide zone is often heavily charged with galena and iron pyrites, the former being a sure indication of the presence of gold. To the eastward or upon the footwall side of the ore body, a belt of indurated and highly fissile schist is encountered at several points in this mine, where cross-cutting has been done in that direction; this is clearly a thrust plane and is said to cause a fall in the ore values when it approaches the lode.

Upon the western side or hanging wall, a large well-defined quartz body, very heavily charged with pyrites, called the mineral lode, has been cut at several points, but this body carries very little gold.

Driving in this mine along the course of the lode has failed so far to disclose any other ore bodies, but in order to make this prospecting thorough, the country should be cross-cut, at intervals of at least every 50 feet to the schist on the one side and the mineral lode on the other; should this fail to disclose the presence of other chutes, it may be assumed that the veins in this mine do not extend north and south beyond the buckled area referred to above, in which, however, there is still the chance of other veins being picked up, and this point should be determined before any further exploration is undertaken.

Since these veins are apparently filled by percolation and have proved to be more numerous, of greater size and richness in the upper levels, prospecting in that portion of the mine would offer greater possibilities than the lower levels, but at the same time veins cut in the latter are almost certain to extend into the former, but on

the other hand those met with in the former may or may not extend into the latter. This lode on the whole has been free from trouble, the first fault being met with near the bottom of the mine; this threw the reef several feet to the eastward, but upon a second fault being encountered further work was abandoned since the stone was not only small and of little value but there was no great distance to drive to the boundary of this property.

*Table showing the Yield of the Queensland Menzies Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1896 ...	Wedderburn, G.M.L. 2886z ...	41'00	251'78	6'14
1897 ...	Do. " ...	4,031'00	12,856'03	3'19
1898 ...	Do. " ...	2,429'00	6,894'27	2'83
1899 ...	Do. " ...	3,500'00	7,801'38	2'25
1900 ...	Do. " ...	3,143'00	6,113'98	1'94
1901 ...	Do. " ...	2,962'00	6,621'68	2'57
1902 ...	Do. " ...	5,155'00	8,124'33	1'57
1903 ...	Do. " ...	7,249'00	10,029'75	1'38
1904 ...	Do. " ...	9,973'00	6,874'46	'69
1905 ...	Do. " ...	6,368'00	8,241'21	1'29
	Total ...	44,851'00	73,806'82	1'64

The Oceanic, G.M.L. 4969z, adjoins the Wedderburn upon the east, and covers a portion of the township. It is now the property of the Queensland Menzies Co., but was worked as G.M.L. 4920z in 1899, when 101'00 tons of stone were crushed, yielding 62'13 ozs. of gold. Since then the Company has crushed 50'00 tons, which yielded 26'52 ozs. of gold.

The Menzies Gold Reefs Proprietary, Ltd., which has now amalgamated with the Menzies Crusoe Gold Claims, Ltd., under the title of the Crusoe Gold Claims, Ltd., originally owned a large number of leases, situated at different parts of this district, but finally abandoned all with the exception of the Friday G.M.L. 2825z and Naida G.M.L. 3016z, and it was upon the former of these that all the work was concentrated in what was known as the Friday mine.

This mine is situated to the southward of the Queensland Menzies, and to the westward of the town, at about the centre of the main auriferous belt. It was taken up in the year 1895, and was shortly after inspected by Mr. H. Y. L. Brown, who says:—"This possesses a well-defined quartz reef, having a strike north-west and northerly, and dipping south-west at an angle of about 40 degrees. The veinstone consists of bluish, laminated, and veined quartz, containing galena, pyrites, and coarse gold." \*

\* Loc. cit., p. 4.



This mine has now been completely closed down for some years; the following information is, therefore, taken entirely from the working plans, records, and information obtained from reliable sources (Plate IV.).

There are three main levels in this mine: No. 1, or 80-feet, is 350 feet long; No. 2, or 150-foot level, is 450 feet long; No. 3, or 200-foot level, is 500 feet long; whilst from the No. 3 level a winze has been sunk to a depth of 100 feet upon the underlay of the lode, and from it a level has been driven for a distance of 70 feet at a vertical depth of 240 feet, or 30 feet from the bottom of the winze. In the Menzies United, Ltd., property, which adjoins this lease to the south, the continuation of this lode was cut, and proved to be of no value, and died out at the 388-foot level.

Two underlay shafts connect the No. 1 level with the surface, whilst a main vertical shaft has been sunk to the 200-foot level. A crosscut has been driven from the 150-foot level 180 feet east, where a mineral lode was cut, which is evidently the same reef as outcrops at the surface, near the eastern boundary.

Judging from the plan a defined ore-shoot with a southerly dip was worked down to the 200-foot level beneath which it tapered off into a pipe, becoming small and low in value, until work was abandoned before the boundary was reached. This ore body dipped at an angle of 53 degrees at the north end but flattened to 40 degrees towards the south; the thickness of the stone is said to have ranged from three to 18 inches.

Good stock water was struck at a depth of 129 feet, the daily yield being estimated at 500 gallons.

This reef was evidently of the lenticular fissure type, and probably consisted of a series of pipes, which become more or less united in the upper levels; the southernmost one, as is generally the case, extended to a greater depth than the others. The continuation of this shoot was cut in the Menzies United, Ltd., lease Balkis, which adjoins and will be mentioned later.

With the exception of the crosscut east to the mineral lode mentioned above, little prospecting has been done to prove the existence of other lodes, whilst upon the Naida, which adjoins to the north, and upon which the battery is located, absolutely no work has been done.

Since these leases (the Friday and Naida, which are now held) are situated in the very heart of the auriferous belt, it is very probable that other reefs may exist beneath the alluvial covering; this could be determined by trenching and crosscutting for a fairly moderate cost.

It was mentioned previously that the Queensland Menzies shoot was lost on a fault near its boundary; had this continued it would have extended into the Naida, which adjoins it to the westward. Judging, however, from the character of the vein at the bottom of

**BULLETIN N°22 PLATE IV.**

tered since their abandonment without result.

g, however, from the character of the vein at the bottom of

mine, there is little prospect of stone of any value continuing, though a small pipe of quartz may do so.

*Table showing the Yield of the Friday Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
					Ore crushed.	Gold therefrom.	
		tons.	ozs.	ozs.	tons.	ozs.	ozs.
86.	Friday G.M.L. 2825z	2,272.00	2,986.17	1.25			
87.	Do. "	2,531.00	3,640.21	1.04			
88.	Do. "	501.00	3,234.25	6.45			
89.	Do. "	6.7.0	981.18	1.48	5,971.00	9,802.09	1.64
90.	Do. 4939z	37.00	877.86	23.73			
91.	Do. "	16.00	38.16	2.26			
92.	Do. "		465.26		53.00	1,379.23	26.12
93.	Do. 5013z		94.51				
94.	Do. "	39.00	17.71	.45	39.00	112.22	2.87
95.	Do. "						
	Total				6.03.00	11,293.50	1.86

**The Menzies United Mines, Ltd.**—This Company owned a group of leases to the westward of the Friday, upon one of which, called BALKIS, G.M.L. 3151z, a deep shaft was sunk with the object of cutting the underlay of the Friday load. The position chosen for his shaft was unfortunate, owing to the fact that no allowance was made for the southerly pitch of the ore-shoot (which at the time was probably not demonstrated); this necessitated extension driving through barren ground in a southerly direction in order to pick it up, this work being of absolutely no value from an exploratory point of view.

At a vertical depth of 388 feet, a level was driven south from the main shaft for a distance of 330 feet, when it encountered a small vein which split into two to the southward. (Plate IV.)

At the junction of the two veins a rise was carried up on this small ore body towards the Friday boundary, and a small intermediate level driven south 65 feet. A small parcel of stone was crushed from this rise and level but the vein was too small to be remunerative. Two crosscuts were driven, one east and one west, from the 388-foot level to the northward of the ore-shoot in which nothing was cut resembling a formation.

At a depth of 150 feet stock water was cut, which yielded a supply of about 400 gallons per diem.

Upon the leases owned by this Company a total of about 2,000 feet of sinking and 2,500 feet of driving has been done without result.

The Balkis is at present held by the Menzies Mining and Exploration Corporation, Ltd., which Company has failed to prove the lease of any value, whilst the others have been pretty well prosecuted since their abandonment without result.

From this lease 132 tons of stone have been crushed, which yielded 138ozs. of fine gold.

**The Central Menzies Gold Mines, Ltd.**—This Company also owned a lease called the Emulator, G.M.L. 2834z, which lies to the north of the Friday, upon which 484 feet of sinking and 790 feet of crosscutting was done with the object of cutting the northern extension of that reef. All this work, however, proved to be valueless.

The only crushing from this lease was in 1900, when 19·00 tons were treated, and yielded 18·15ozs. of gold.

**The Menzies, Ltd.**—This was another of the old Exploration Company's, that held a number of leases, consisting of the Lady Shenton North, G.M.L. 2826z, Florence North, G.M.L. 2828z, Pericles, G.M.L. 2829z, Shirkin, G.M.L. 3050z., Fennine, G.M.L. 3051z, Bantry, G.M.L. 3055z, and Stuart, G.M.L. 3056z. Upon these leases, with the exception of the Shirkin, of which lease no plans exist, 700 feet of sinking and 1,360 feet of driving was done, the only reproductive work being upon the Shenton North, where the outcrop of a lode was worked which dips into the Leonidas.

This Company appears to have abandoned these leases in 1901, when they were retaken by the various Companies and parties of working miners.

**Flying Fish Leases.**—These leases are situated upon a portion of what was originally the Shirkin, which lies upon the south-west side of the town, and to the north-east of the Friday. They have been worked continuously since 1901 upon some small but rich quartz veins of the usual segregation type in the oxidised zone.

*Table showing the Yield of the Flying Fish Reefs.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
					Ore crushed.	Gold therefrom.	
		tons	ozs.	ozs.	tons	ozs.	ozs.
1901 ..	Flying Fish G.M.Ls. 4982z, 4991z	56·00	98·19	1·81			
1902 ...	Do. ...	107·70	472·78	4·39			
1903 ...	Do. ...	46·30	159·69	3·47	209·50	730·66	3·46
1903 ...	Flying Fish G.M.L. 5089z	180·00	548·16	3·04			
1904 ...	Do. "	215·00	447·58	2·08			
1905 ...	Do. "	304·00	265·58	·87	699·00	1,261·32	1·80
	Total ...	...	...	...	908·50	1,991·96	2·19

**The Lady Shenton North.**—This lease, as stated above, was worked by the Menzies, Ltd., from 1898 to 1900, after which it was abandoned, since which it has been taken many times in varying forms by working miners, who have pretty well riddled the ground from the old workings to the surfaces of a lode which outcrops upon it, but underlies into, and has been worked upon, the Leonidas, the adjoining lease to the westward [756.]

Table showing the Yield of the Lion Reef.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
					Ore crushed.	Gold therefrom.	
1898	Lady Shenton North	tons. 69.00	ozs. 194.28	ozs. 2.81	tons.	ozs.	ozs.
	G.M.L. 283z						
1899	Do.	116.00	220.85	1.19			
1900	Do.	58.00	42.15	0.79	303.00	457.23	1.49
1901	Success G.M.L. 468z	110.00	78.77	0.71			
1902	Do.	10.0	35.32	3.53	120.0	114.09	0.95
1902	Rescue G.M.L. 5065z	15.00	22.88	1.88			
1903	Do.	33.00	56.68	1.71	48.00	79.06	1.64
1903	Lion G.M.L. 5069z	48.00	115.91	2.41			
1904	Do.	8.00	7.21	0.90	56.00	123.12	2.19
1904	Sentinel G.M.L. 5204z	50.00	31.88	0.63			
1905	Do.	5.00	3.72	0.74	55.00	35.58	0.64
1905	Lion G.M.L. 5244z	43.00	56.70	1.32	43.00	51.70	1.33
	Total	...	...	...	630.00	865.78	1.37

The Leonidas, G.M.L. 2882z.—This lease, which is the property of the Menzies Mining and Exploration Corporation, Ltd., runs in a more easterly direction than is usual; it was taken up on the dip or western side of a line of lode which outcropped in the Shenton North and Pericles.

There are three groups of workings which may be upon dislocated portions of the same vein, the outcrops of which were worked in the Shenton North to a depth of 100 feet below which it passed into this lease.

At the end of this lease a vertical shaft has been sunk to a depth of 130 feet, from which a level has been driven 70 feet north and 110 feet south, a winze was also sunk upon the lode; and another level driven at 172 feet, north 90 feet and south 110 feet, the reef averaging here a little over 12 inches in thickness, worth 13dwts.

The water-level in these workings was 152 feet, the yield being 150 gallons of salt water per diem.

A little south another vein which outcrops in the Shenton North has been worked by two vertical shafts to the 77-foot level, which is 150 feet long, from which the lode was winzed down on to the 122-foot level, and from this depth the lode was driven on for a length of 300 feet; from the other shaft, a winze was sunk to the 170-foot level which was carried on for a distance of 70 feet.

Farther south but still upon the north-eastern boundary, another small quartz vein has been worked by a vertical shaft to a depth of 143 feet, and a level driven 220 feet, the reef at this level averaging about 12 inches, worth about 10dwts. The returns furnished by the manager are as follow:—3,457 tons of stone have been crushed, which yielded 2,948.71ozs. of fine gold.

**The Florence Gold Mines, Ltd.**—This property, which consists of the Florence G.M.L. 2821z, Pericles G.M.L. 2829z, Florence Extended G.M.L., 5203z, and Bantry G.M.L. 3055z, is situated upon the main auriferous belt north and adjoining the Lady Shenton and south of the Friday.

The whole of the work done by this Company may be said to be confined to the Florence lease, the first start being made by sinking a main shaft to a depth of 210 feet near the centre of the property with the object of cutting the Lady Shenton lode. From this shaft cross-cuts were driven in a north-easterly direction at the 60-foot level for a distance of 435 feet, at 110 feet for a distance of 173 feet, and at 160 feet for a distance of 142 feet. In the 60-foot cross-cut a small body of stone was cut dipping south at a distance of 285 feet from the shaft, which was driven on 27 feet west and 135 feet east; this level is connected with the surface where this reef outcrops by an underlay shaft.

This vein was also cut in the two lower cross-cuts, being driven on for a distance of 30 feet east at the 110-foot level and 75 feet west and 90 feet east at the 160-foot level. At the end of this eastern drive, a cross-course dipping to the northward was cut and followed east for 16 feet. This cross-course is evidently the same as outcrops at the surface to the southward of the main shaft. At 200 feet from the surface a small drive east and west was driven from the shaft.

In 1898, the Shenton Company having traced one of these reef shoots up to the south boundary of the Florence, work was started in that locality and what is called the New Main Shaft sunk to a depth of 300 feet and the reef worked by means of three levels. This reef proved to be the top of the Shenton northern shoot which was found to be considerably broken in the lower levels by cross-courses in both properties and to die out before reaching the 300-foot level, whilst to the northward the top of the shoot which dips south ended abruptly upon coming in contact with an east and west cross-course dipping north. This cross-course which terminates the lode has been met with at a distance of 40 feet north of the boundary in the 60-foot level, 100 feet in the 150-foot level, while in the 200-foot level it was cut at a distance of 135 feet but the level was not continued because the ore-shoot stops on another cross-course met with in this level at a distance of 80 feet from the boundary which governs its northern extent down to the 260-foot intermediate level below which there is no stone. (Plate V.)

A winze was sunk on the formation from the bottom of the main shaft for a depth of 213 feet, but in it no stone was cut. At 150 feet from the surface the level was continued beyond the cross-course for a distance of 135 feet, from which point cross-cuts were driven 100 feet both east and west without result and thus proving that the Shenton reef did not continue north.

**BULLETIN N°22 PLATE V**

**over 100 feet by rich specimens scattered up**



re Shenton reef did not continue north.

One of the porphyritic dykes crosses this lease between the two main shafts striking west-north-west and follows the outcrop of the Leonidas lodes, whilst another branch from it was cut in the old main shaft, from which point it appears to run north-west, being cut in the Pericles [6343] and the cross-cut in the Shenton North. These dykes in no case where observed appear to have caused any disturbance so far as the lodes are concerned, since these latter often cross or follow them [6342].

A number of other small segregation veins which cross this property upon the normal north-westerly course have been opened up and are still being worked in the oxidised zone; it is from this source that the entire production of the mine has been derived for the last year or two.

At the north-east corner of the lease is a water-shaft called the donkey shaft, in which the water-level is 200 feet, the yield being estimated at 6,000 gallons per diem, and is stated to be suitable for stock. There is also a water-shaft on the Florence Extended, G.M.L. 5203, which was originally the Fenine, G.M.L. 3051, being 213 feet in vertical depth with a cross-cut west 241 feet and east 120 feet at the 157-foot level and 40 feet east at the 213-foot level. In the Pericles, a shaft has been sunk to a depth of 100 feet and a cross-cut driven 231 feet in a north-east direction in which only small veins of stone were cut.

*Table showing the Yield of the Florence Reefs.*

Year	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1896 ...	Florence, G.M.L. 2821z ...	300 00	465 29	1 55
1897 ...	Do. " ...	...	129 82	...
1898 ...	Do. " ...	185 00	439 20	2 37
1899 ...	Do. " ...	1,205 00	842 05	70
1900 ...	Do. " ...	1,735 00	1,430 50	82
1901 ...	Do. " ...	1,252 00	1,082 86	86
1902 ...	Do. " ...	415 00	460 81	96
1903 ...	Do. " ...	365 00	352 56	97
1904 ...	Do. " ...	591 00	547 78	91
1905 ...	Do. " ...	616 00	664 01	1 08
	Total ...	6,664 00	6,354 85	95

**The Lady Shenton Gold Mine, Ltd.**—This mine, which is situated to the southward of the town, upon G.M.Ls. (1380), 2820z, and 346z, was not only the first discovery made in this district but it also proved to be by far the richest.

It was discovered in September, 1894, by Messrs. Menzies and McDonald, who were able to trace the outcrop of the lode for a length of over 100 feet by rich specimens scattered upon the surface.

In 1895, Mr. H. Y. L. Brown writes:—"This is on two quartz reefs, one of which strikes north 20 degrees west, and the other east and west. The angle of the underlie averages 45 degrees, but in some places it is less. The gold occurs in quartz, and is often associated with galena and zinc blende. The rocks consist of argillaceous talcose schist above the water-level, with hornblendic slate below. In connection with the quartz-reefs, there is a soft soapy clay which is apparently a decomposed felspathic rock; other shafts near are sunk in green chloritic talcose and argillaceous schists and brown decomposed igneous rocks." \* [1036-1044.]

This mine is now full of water to a little above the No. 6 level, whilst above the No. 5 level, which is the lowest that is accessible, practically all the ore has been stoped and most of the stopes filled in. Lately this mine has been in the hands of tributers who have not improved matters from an inspection point of view, since in working portions of the reef which were much disturbed or considered too small by the Company a considerable quantity of rock had to be broken which was not worth raising and was therefore packed below, thus blocking up places that were accessible before.

Both in the stopes and levels very large excavations have been taken out in places; these however do not, it is stated, represent the size of the quartz-vein, but either the enriched rock zone adjoining or a series of veins with interbedded rock.

The mine was first opened by underlay shafts from the surface by means of which some very rich stone and enriched decomposed rock (formation) was worked, but later on a vertical shaft was sunk to a depth of 200 feet where it cut the lode in the hard sulphide zone, and from the bottom of this shaft the No. 4 level was driven. Above this level the country softens rapidly, passing from schistose rock into a yellow and brown argillaceous formation. The Nos. 5 and 6 levels were worked by a winze sunk close to the shaft bottom, whilst another main winze was sunk further north from the No. 5 to the No. 8 level. (Plate V.)

In the west lease a main shaft was sunk in very hard country to the dip called Ray's shaft to a depth of 620 feet; this shaft is now connected with the Nos. 8 and 9 levels by cross-cuts. [6341.]

Although no water was encountered in the original workings it was cut in this shaft at a depth of 100 feet, below which a water-bearing zone of 200 feet was passed through, the yield varying from 1,000 to 6,000 gallons per diem.

All the stopes are situated above the No. 6 level, for below this, in spite of the fact that a strong reef was followed down upon which a considerable quantity of work has been done, no ore of a payable character was met with.

The ore-body in this mine was of a composite character, i.e. it consisted of a number of more or less lens-shaped quartz veins or

\* *Loc. cit.*, p. 4.

pipes (elongated lenses) which follow the foliation planes of the rock in a south-westerly direction, the dip of the planes varying here from 53 degrees at the north end of the mine to 45 degrees at the south.

The auriferous veins lie upon these planes, dipping diagonally across them at an angle of 84 degrees to the southward, thus the northern shoot that was worked in the Florence dips into the Shenton whilst the main shoot in this mine dips into the Alpha.

In the oxidised zone the character of these shoots was not well defined owing to the presence of a large number of minor veins and the enrichment of the adjoining decomposed rock due to concentration; as a consequence the true character of this ore body was not understood until the more solid country was reached where the veins began to contract into pipes. The impression gathered with regard to this lode some years ago was that a large rich formation enclosing a more or less broken quartz reef extended from one end of the upper levels to the other; whilst in the sulphide zone the quartz-reef had formed into a definite solid body of variable size enclosed in a formation the walls of which had not been cut.

Near the surface the whole of the stone and formation was worked for a length of something over 600 feet, whilst below this the breadth of the ore body steadily increased until at the No. 4 level (200 feet) it extended for a length along the levels inclusive of the Florence of over 1,000 feet. Directly this level was passed and the sulphide zone entered the lode split up into three definite shoots with blank ground between them, whilst below the three shoots gradually contracted until at a vertical depth of about 300 feet they died out altogether.

The quartz in this mine has no defined walls or casing, and where a semblance of a wall is met with it is found upon careful examination to be only one of the cleavage planes of the rock upon which the vein has been formed. Individual quartz-veins, as far as can be judged from the small veins now being worked, have no connection with each other but lie upon parallel planes of cleavage often overlapping each other, or in the case of three may lie in a splice-like manner. No signs of fissure plane can be observed although often in driving small threads of quartz have been followed for a considerable distance, which gave the impression that such a plane was being followed. These veins were often most misleading, since upon several occasions in this mine these were followed until they died out, whilst other ore-bodies existing upon parallel planes were missed and not discovered until later by cross-cutting. The ore-body in this mine is considerably disturbed by a series of cross-courses, some of which are represented by solid barren quartz-veins. These cross-fissures, which mostly run in a more or less east and west direction and dip to north, generally follow the cross joints of the rock and have in cases displaced the ore body, the throw being either east or west according to whether

they are normal or reversed faults. They are in all probability inclined V faults, the southernmost of the pair being more oblique than the northern.

In places in this mine two or more minor faults have apparently intersected the lode in close proximity, causing such considerable disruption that even driving the levels through them was attended with considerable danger and difficulty, whilst certain portions of the ore-body could not be worked. This ore in many places has now been taken out by the tributers but it shows in the accompanying plan of the stopes as solid ground. (Plate No. V.)

Although these faults have undoubtedly caused considerable trouble in places it is quite apparent that many of the so-called displacements are nothing of the kind but simply represent the southern termination of one vein, whilst another has been met with upon parallel planes either east or west.

At the present time about the only point in the mine where the true pitch of the ore-pipes can be observed is in what is called the P. Grade, which is situated near the north-east corner of the Alpha between Nos. 4 and 5 levels. The shoot here has a well-marked pitch of about 34 degrees south, but comes to a sudden stop upon the cross-course which has at this point dislocated the lode. If the grade of this shoot is followed upwards to the surface through the oxidised zone it will be found to cross the No. 2 level to the eastward of the main shaft and to come out upon the surface at the point where the original rich outcrop was discovered, whilst if followed downwards after allowing for the throw it will be found to continue to the bottom level of the Alpha. If this is taken as the true dip of the ore-shoots in this mine (which is supported by the fact that the grade is identical with the ore-shoots in the other mines) it becomes apparent at once that there are three main shoots all of which terminate at the No. 6 level, whilst at the south end there is either another short one or, which is more probable, it represents the splaying out of this shoot similar to the Queensland Menzies. This is not at all an uncommon characteristic of this class of lode, the ore-body presenting the appearance of a series of inclined V's, the apex of which points south, the lower side dipping at an angle of about 35 degrees, whilst the upper, which is much more acute, is bounded by a line which dips at an angle of from 70 to 75 degrees; this is on the inclined plane, not as appears in the foreshortened vertical section of the ore-shoots, Plate V.

This splaying out of the ore-shoot towards the surface in a more or less vertical manner causes the various distinct chutes met with below to unite in the upper levels and in consequence to appear like one continuous ore-body.

It is not at all clear that the strong reef which is reported to have been cut in the workings below the No. 6 level is the

continuation of the rich ore body worked above, but this point could not be investigated on account of the water. It would be quite exceptional to find a vein of this class continuing strongly in depth without gold values, the usual character being for a rich vein to gradually decrease in size and to finally die out, and this is said to have been the case at the terminations of the ore-shoots at the No. 6 level. It is quite possible that a barren lenticular body has formed at most generally parallel to these termini, but it is much more probable in this case that the barren footwall reef has been cut and followed down since this has the appearance of being a much more permanent body.

In any case the deeper workings are so situated as to have little prospect of cutting the ore-shoots if they continued, and as will be seen by reference to Plate No. V. that, the No. 7 level and the extension south end of No. 8 could only possibly have cut the Florence shoot, which being the northern chute, if this ore-body follows the general character, would be the least likely to continue.

The other ore-shoots lie well to the southward of these workings and would rapidly cross the boundary into the Alpha, this however is apparently not the case as is demonstrated by the extensive works carried out upon the last-mentioned property, a description of which will be given next.

The cross-section of the mine reproduced was prepared by Mr. Robert Falconer, the manager, and shows the relation of the Shenton lode to a granite dyke which lies to the eastward. (Plate V.)

This dyke can be traced at points upon the surface and by the dumps along its course for a considerable distance, and is the same which crosses the Florence Mine after splitting into two branches. Although a solid porphyritic granite was cut in the bore at the bottom of the main shaft and also in the extension east of the No. 8 cross-cut, this dyke has been subjected to the same conditions such as hydration with attendant crushing that have changed the diorite into schists, the alteration in this case being from granite to gneiss, gneiss to mica and sericite schist, the foliation of which is identical with that of the surrounding rocks. [6336.]

This added to the fact that in no instance has a dyke been known to dislocate a lode whilst the quartz-bodies are found in and crossing them proves their prior existence to the lodes, which latter were apparently not formed until after hydration had taken place.

This Company has employed every practicable means at its disposal in order to determine the extension of the ore-body, its leases being riddled with drives, cross-cuts, winzes and bore-holes; therefore with the exception of small parallel pipes of stone there is apparently little prospect of a continuation of the ore-shoot being discovered.

Table showing the Yield of the Shenton Reef.

Year.	Name and Number of Lease.				Ore crushed.	Gold therefrom.	Rate per ton.
					tons.	oss.	oss.
1896 ...	Lady Shenton, G.M.L. 2820z	...	...	...	1,749·00	5,833·92	3·34
1897 ...	Do. do. " ...	...	...	...	4,832·00	14,137·92	2·92
1898 ...	Do. do. " ...	...	...	...	7,328·00	20,090·48	2·73
1899 ...	Do. do. " ...	...	...	...	13,779·00	19,536·48	1·41
1900 ...	Do. do. " ...	...	...	...	16,341·00	17,552·40	1·08
1901 ...	Do. do. " ...	...	...	...	14,938·00	19,306·17	1·29
1902 ...	Do. do. " ...	...	...	...	15,900·00	17,508·18	1·10
1903 ...	Do. do. " ...	...	...	...	16,152·00	13,587·07	0·84
1904 ...	Do. do. " ...	...	...	...	1,119·00	675·87	0·60
1905 ...	Do. do. " ...	...	...	...	4,091·00	3,872·82	0·95
	Total	...	...	...	96,280·00	132,101·31	1·37

NOTE.—This reef should be credited with some 5,000 oss. from the Florence and 10,000 oss. from the Alpha, but no record of the exact quantity obtained from it is available.

**The Menzies Alpha Leases, Ltd.**—This property, which consists of the Stirling, G.M.L. 3031z, and the Alpha, G.M.L. 3011z, is situated immediately south of the Lady Shenton, but it was not until 1900 that the rich ore-shoot worked in that mine was found to extend into this property. Previous to this mining had been carried on upon the Stirling lease upon a reef which crossed the boundary about 160 feet from the north-east corner peg, which was supposed to be the extension of the Shenton reef; this now appears either to be the displaced continuation of the barren reef which lies to the eastward or upon the footwall side of it, or a pyrites lode which has been met with in the mine upon the hanging wall side. At the south end of this reef, which outcrops for a distance of about 300 feet, a vertical shaft, called Armstrong's shaft, has been sunk to a depth of 276 feet, which passed through the reef at 150 feet. At a depth of 205 feet a crosscut was driven 25 feet west, at which point it cut the reef and followed it for a distance of 40 feet. From the bottom of the shaft a crosscut was driven 110 feet to the eastward, but in it no lode was cut [750, 754].

A bore was then put down at the north-east corner peg, which cut the lode at a depth of 250 feet. A main shaft was sunk 123 feet south of this point to a depth of 335 feet, with a crosscut at 250 feet from which No. 1 level was driven, whilst No. 2 was driven from the bottom of the main shaft. (Plate V.)

In the No. 1 level the ore body extended south for a distance of 220 feet from the Shenton boundary, after which it died out, no continuation of it being discovered in the level which was continued for another 120 feet.

The No. 2 level was driven from the main shaft north to the boundary where the small terminal points of the shoot were met with; in places this also continued for 40 feet south of the shaft,

after which no further ore was discovered, although 480 feet were driven in hard aphanatic diorite [6330].

In this level the last 300 feet were driven in a solid, barren quartz reef, which gradually formed and which is, in all probability, the same vein as was cut in the Armstrong shaft; however, no connection between these workings has yet been made.

From this level a considerable amount of crosscutting and boring has been done without result, whilst, from the bottom of the main shaft, a winze has been carried down on the dip of the formation for a further distance of 363 feet. From this winze a certain amount of boring and crosscutting has been done, which must, if the Shenton ore-shoot extended in this direction, have cut it, or, at least, some indication of it.

From this, it appears that the Shenton ore-shoots do not extend below the No. 2 level in this mine, which is the continuation of the No. 6 in the other, or, in other words, these veins cease to exist below the level to which the action of hydration has extended.

Upon the Alpha lease, which lies to the southward of the Stirling, a considerable amount of work has been done upon some small rich reefs that were met with near the south-east corner; one of these, which follows the general north-west course, has been worked by a number of underlay shafts to a depth of 60 feet, and, below this, by means of a winze to 100 feet. From this reef some rich stone was raised; but, since it is small, and the country hard below the existing workings, it has not been considered advisable to continue deeper. The line of the reef northward seems pretty constant, to judge by the number of prospecting shafts sunk upon it, but, immediately south, on approaching the Little Wonder, it is extremely broken, the dip changing even in a short distance.

*Table showing the Yield of the Alpha Reefs.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1896 ...	Menzies Alpha Leases—Stirling, G.M.L. 3081z, and Alpha, G.M.L. 3011z	53'00	324'55	6'12
1897 ...	Do. " ...	427'00	1,164'70	2'72
1898 ...	Do. " ...	263'00	1,431'52	5'44
1899 ...	Do. " ...	199'00	559'35	2'81
1900 ...	Do. " ...	200'50	239'37	1'19
1901 ...	Do. " ...	676'50	822'42	1'21
1902 ...	Do. " ...	3,853'00	4,020'76	1'04
1903 ...	Do. " ...	4,746'50	6,015'21	1'26
1904 ...	Do. " ...	343'50	476'27	1'38
1905 ...	Do. " ...	311'00	483'59	1'56
	Total ... ..	11,073'00	15,537'74	1'40

The Alpha South, G.M.L. 3098z, is situated south of the Alpha, and was until quite recently held by the Menzies Mining and



Exploration Corporation, Ltd. Little work has been done upon it; the deepest shaft being 80 feet, from which 65 tons of stone were crushed, yielding 64·40ozs. of gold.

The Meriyulah, G.M.L. 4960z, is situated south of the Alpha South, and upon it some small quartz veins have been worked in the oxidised zone for the last six years.

*Table showing the Yield of the Meriyulah Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1900 ...	Meriyulah G.M.L. 4960z ...	9·00	10·93	1·21
1901 ...	Do. " ...	37·00	62·76	1·69
1902 ...	Do. " ...	23·00	30·18	1·31
1903 ...	Do. " ...	22·00	28·83	1·31
1904 ...	Do. " ...	107·00	91·12	·84
1905 ...	Do. " ...	107·00	120·13	2·05
	Total ...	305·00	343·95	1·12

The Heart's Content, G.M.L. 4947z, is a small lease which lies to the south of the last, and was worked in the years 1900 and 1901, a shaft being sunk to a depth of 70 feet on a small quartz vein from which 44 tons of stone were raised which yielded 82·37ozs. of gold.

**The Menzies Mining and Exploration Corporation, Ltd.**—This Company owns a number of leases mentioned previously under their distinctive names, but this group of leases which constitute the head quarters of the Company consist of the Castle Blarney, G.M.L. 3106z; Lady Shenton East, G.M.L. 2843z; Lady Shenton Extended, G.M.L. 2844z; and Shenton South East, G.M.L. 4948z, all situated to the eastward of the Lady Shenton.

In the Extended, a small cross vein which strikes a little east of north, and dips to the south at an angle of 45 degrees has been worked by means of two underlay and one vertical shaft to a depth of 158 feet. From these levels have been driven at 62 feet, 200 feet long; at 99 feet, 200 feet long; and at 146 feet, 130 feet long, and from these workings 1,453 tons of stone were raised and crushed, yielding 1,157·47ozs. of fine gold.

On the Shenton East, an east and west reef consisting of two parallel pipes of stone have been worked to a depth of 199 feet by three underlay shafts with short levels and crosscuts, at 51 feet, 85 feet, 122 feet, 164 feet, and 199 feet. A main vertical shaft has also been started and sunk to a depth of 218 feet, but it has not yet been connected with the other workings on the lode. In this shaft, a supply of good stock water equal to 1,000 gallons per diem was cut at a depth of 155 feet. From this mine 1,770 tons of stone were crushed, which yielded 2,440·12ozs. of gold. The veins cut and worked in these two properties do not appear to be cross courses, but have simply been formed by the buckling of the strata.

The Shenton South-East, G.M.L. 4948z, is south of the Lady Shenton and Shenton Extended; it consists of portions of the Lady Shenton No. 1, G.M.L. 2824, and Lady Shenton South Extended, G.M.L. 3458z, the former of which was owned by the Menzies Gold Reefs Proprietary, Limited, who sank a shaft 100 feet and crosscut from the bottom 450 feet west in the hopes of cutting the Shenton lode; they also sank two shafts near the north boundary which are connected by a crosscut 150 feet long. With the exception of this, little work has been done upon this lease from which a parcel of 37 tons of stone was crushed, yielding 37·80ozs. of gold. Upon the Castle Blarney, which lies to eastward of the Extended and between it and the Railway, a few prospecting shafts have been sunk, the deepest of which is 50 feet.

**The Golden Age or Little Wonder Group.**—This group of leases cover, or at one time have covered, portions of the old leases Golden Age, G.M.L. 2,830z; Adelaide, G.M.L. 3378z; and Lady Shenton No. 1, G.M.Ls. 2424z and 3074z.

The Golden Age was worked in the earliest days of this field by the Menzies Golden Age Gold Mine, Limited, upon a small but rich east and west reef, the shoot in which dips to the south to the 80 feet level, beneath this, although considerable prospecting was done in serpentine schist, no continuation of the vein was met with. Five shafts were sunk, the total depth of which is 730 feet, the deepest being 260 feet, in which the water level was cut at 173 feet; besides these shafts 180 feet of winzing has been done, 1,470 feet of drives and crosscuts. The lode is apparently of the buckled type as there is no indication of a cross reef, the only outcrop being a large pyrites body which follows the normal course and is probably the same as cut to the northward in the Shenton No. 1.

In some portion of this mine the porphyritic granite dyke was cut out, and from these dumps a finer series of specimens were obtained illustrative of its gradual change into sericite schist [632-4]. Portions of this lease have more recently been worked as the Federation, G.M.L. 4959z; and Golden Age, G.M.Ls. 5005z, and 5092z, whilst the Little Wonder also occupies a part.

*Table showing the Yield of the Golden Age Reefs.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
					Ore crushed.	Gold therefrom.	
1896	Menzies Golden Age, G.M.L. 2-30z	tons. 50·00	ozs. 285·48	ozs. 5·70	tons. ...	ozs. ...	...
1897	Do. ...	202 50	722·20	3·56	...	...	...
1898	Do. ...	...	...	...	...	...	...
1899	Do. ...	40·00	51·32	1·28	292·50	1,599·0	3·62
1900	Federation, G.M.L. 4959z	30·00	13·19	·43	30·00	13·19	·4
1901	Golden Age, G.M.L. 5005z	31·00	27·75	·89	...	...	...
1902	Do. ...	45·0	13·34	·29	76·00	41·9	·54
1903	Do. 5092z	27·00	46·69	1·73	...	...	...
1904	Do. ...	10·00	1·96	·19	...	...	...
1905	Do. ...	10·00	6·20	·62	47·00	54·85	1·17
	Total ..	...	...	...	445 50	1,168·13	2·62

The two leases named **Lady Shenton No. 1—28247z** and **3074z**, which were owned by the **Gold Reefs Proprietary, Limited**, have, besides the **Shenton South-East, G.M.L. 4948z**, in the north, being divided up into the **Menzies Main Reef, G.M.L. 5149z**; **Golden Crown, G.M.L. 4973z**; **Hayles and Taverstocks United, G.M.L. 5000z**; **Little Wonder North, G.M.L. 5171**; and the balance of the **Little Wonder, G.M.L. 5189z**.

The original Company, besides the 450 feet and 150 feet of crosscutting mentioned previously, sank several shafts, in one of which a large pyrites lode assaying from two to three penny-weights was cut at 100 feet, being probably the same as that met with in the **Golden Age, G.M.L. 2830z**.

Upon these minor leases, as a rule, little has been done with the exception of raising a little stone from the old workings.

*Table showing Yield of Gold from the above-mentioned Leases.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1904 ...	Menzies Main Reef, G.M.L. 5149z ...	37'00	10'00	·27
1901 ...	Golden Crown, G.M.L. 4973z ...	16'00	35'42	2'21
1901 ...	Hayles & Taverstock's United, G.M.L. 5000z	44'00	56'48	1'28
1902 ...	Hayles & Taverstock's United, G.M.L. 5000z	40'00	50'67	1'26
	Total ... ..	84'00	107'15	1'27

The **Little Wonder, G.M.L. 5189z**, is situated to the eastward of the **Alpha South, G.M.L. 3098z**, upon portion of what were the **Shenton No. 1, G.M.L. 3074z**, and the **Golden Age, G.M.L. 3830z**.

There are several lines of stone in this lease, but until recently most of the work was confined to the **Golden Age** and **Central** lines, lately, however, work has been started more to the westward, upon a promising ore body.

*Table showing the Yield of the Little Wonder Reefs.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
					Ore crushed.	Gold therefrom.	
		tons.	ozs.	ozs.	tons.	ozs.	ozs.
1903 ...	Little Wonder, G.M.L. 5139z	14'00	15'96	1'14	14'00	15'96	1'14
1904 ...	Do. G.M.L. 5163z	94'00	329'98	3'51	94'00	329'98	3'51
1904 ...	Do. G.M.L. 5189z	113'00	129'29	1'12	...	...	...
1906 ...	Do. G.M.L. 5189z	163'00	451'80	2'77	276'00	581'09	2'10
	Total ... ..	...	...	...	384'00	927'03	24'1

The Adelaide, G.M.L. 3378z, is an old lease which lies to the eastward of the Golden Age, and upon it a good many prospecting shafts have been sunk. Lately a portion of it has been worked as the Baden Powell, but so far only in the oxidised zone upon small quartz veins.

*Table showing the Yield of the Baden Powell Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1899 ...	Adelaide, G.M.L. 3378z ...	13.50	17.14	1.27
1903 ...	Baden Powell, G.M.L. 5089z ...	17.00	18.20	1.07
1904 ...	Do. 5241z ...	127.00	204.00	1.60
1905 ...	Do. " ...	19.00	8.63	.45
	Total ...	176.50	247.97	1.40

To the south and south-west of these are the Cosmopolitan, G.M.L. 4961z; Broken Seal, G.M.L. 5022z; and Nugget, G.M.L. 5209z, upon which a number of shallow workings have been sunk upon small quartz veins.

*Table showing the Yield of the above-mentioned Leases.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1900 ...	Cosmopolitan, G.M.L. 4961z ...	42.00	18.13	.43
1901 ...	Do. " ...	10.00	5.58	.55
	Total ...	52.00	23.71	.45
1902 ...	Broken Seal, G.M.L. 5022z ...	35.00	25.66	.73
1904 ...	Nugget, G.M.L. 5209z ...	36.00	98.03	2.43
1905 ...	Do. " ...	51.00	46.89	.92
	Total ...	122.00	170.58	1.39

**McClay's Welcome Gold Mining Company, N.L.**—This Company, which owned Taipo, G.M.L. 3744z, and Taipo South, G.M.L. 3840z, which are situated to the southward of the Golden Age, worked these leases in 1897 and 1898 by means of a 62 feet north shaft from which a level was driven south from the bottom for a distance of 113 feet to the next shaft which is 132 feet deep with a level nine feet south at the 120 feet. The south shaft is on the northern boundary of the south lease and is 102 feet deep.

The vein in these workings is small and of low value, being associated with a porphyritic granite dyke [6335].

After the Company abandoned these leases, they have been held under the names of Golden Star, G.M.L. 4907z; Golden

Butterfly, G.M.L. 4997z; Welcome, G.M.L. 5101z; and Homeward Bound, G.M.L. 5173z, but little work has been done of a developmental character.

*Table showing the Yield of McClay's Welcome Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
					Ore crushed.	Gold therefrom.	
		tons.	ozs.	ozs.	tons.	ozs.	ozs.
1887 ...	Taipo, G.M.L. 3744z ...	65'00	36'03	'54			
1888 ...	Do. ...	17'00	12'74	'74	82'00	48'77	'59
1888 ...	Golden Star, G.M.L. 4907z	19'00	14'13	'74	19'00	14'13	'74
1901 ...	Golden Butterfly, G.M.L. 4997z	120'00	36'37	'30	120'00	36'37	'30
1904 ...	Welcome, G.M.L. 5101z	90'00	24'53	'27	90'00	24'53	'27
1904 ...	Homeward Bound, G.M.L. 5173z	33'00	4'82	'14	33'00	4'82	'14
	Total ...	...	...	...	344'00	128'62	'37

The Alexandria, or Sherez, G.M.L. 3098z, is situated at the north end of a parallel line of reef to the westward of the Lady Shenton. A few shafts have been sunk varying in depth from 60 to 100 feet, from which 171 tons of stone were raised, which yielded 201'40ozs. of gold.

The Africander, G.M.L. 5253z, is immediately south of the last mentioned, and upon it a great deal of shallow work has been done, small veins being apparently worked from the surface down in the oxidised zone and for considerable lengths. It has been worked off and on since 1898 either by companies or parties of working miners.

*Table showing the Yield of the Africander Reefs.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
					Ore crushed.	Gold therefrom.	
		tons.	ozs.	ozs.	tons.	ozs.	ozs.
1898 ...	Africander, G.M.L. 3034z	20'00	35'92	1'79			
1899 ...	Do. "	168'00	214'50	1'21	189'00	210'42	1'32
1900 ...	Do. "						
1901 ...	Do. "						
1902 ...	Do. 4984z	42'0	40'62	'96			
1903 ...	Do. "	5'0	15'72	3'14	47'00	56'34	1'19
1904 ...	Menzies Fortuna, G.M.L. 5136z	11'0	118'1	1'00			
1905 ...	Do. "	19'00	20'93	1'10	137'00	139'74	1'09
1905 ...	Africander, G.M.L. 5253z	34'50	38'09	1'10	34'50	38'09	1'10
	Total ...	...	...	...	407'50	424'59	1'19

The London and Coolgardie Explorers, Ltd.—This company owned the Last Chance, G.M.L. 3116z, and Mersey, G.M.L. 3118z, which lie immediately south and east of the Africander, and upon this a good deal of shallow sinking along the course of small ore bodies has been carried on for a number of years.

*Table showing the Yield of the London and Coolgardie Reefs.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
1898 ...	Last Chance, G.M.L. 3116z ...	tons. 110-00	ozs. 218-88	ozs. 1-98
1899 ...	Do. " ...	204-50	150-58	-73
1901 ...	Do. " ...	10-00	12-14	1-21
1902 ...	Do. " ...	16-00	12-63	-78
1903 ...	Do. " ...	31-50	53-97	1-71
1904 ...	London and Coolgardie, G.M.L. 5013z	12-00	6-78	-56
Total		383-00	454-98	1-19

**The Crown Cross Group.**—South of the last mentioned, and upon the same line of country, is the Crown Cross, G.M.L. 4912z, upon which a long line of reefs appears to have been worked by a series of shafts to a depth of about 100 feet. One shaft has been sunk to a depth of 200 feet, which is the water level.

The other leases of this group to the southward also appear to have been continuous lines of reefs, to judge from the old workings.

*Table showing the Yield of the Crown Cross Reefs.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
1897 ...	Crown Cross, G.M.L. 4860z ...	tons. 11'00	ozs. 9'84	ozs. '84
1898 ...	Do. " ...	223'00	172'32	'77
1899 ...	Do. G.M.L. 4912z ...	60'00	160'22	2'67
1900 ...	" " " " " " ...	111'00	346'54	3'09
1901 ...	" " " " " " ...	182'00	455'01	2'50
1902 ...	" " " " " " ...	11'00	8'43	'76
1903 ...	" " " " " " ...	146'00	399'48	2'73
1904 ...	" " " " " " ...	66'50	104'53	1'57
1905 ...	" " " " " " ...	18'00	10'82	'60
	Total ...	825'50	1,666'69	2'01
1906 ...	Ivy, G.M.L. 4942z ...	15'00	1'58	'10
1901 ...	Crown Cross South Extended, G.M.L. 4979z	101'00	498'01	4'53
1902 ...	Westralia Menzies, G.M.L. 5084z ...	...	5'75	...
1903 ...	Do. " ...	50	92'66	184'12
1904 ...	Do. " ...	20'00	32'56	1'14
	Total ...	136'50	630'56	5'17
1900 ...	Nil Desperandum, G.M.L. 4941z ...	74'00	152'55	2'06
1901 ...	Do. " ...	13'00	43'22	3'32
1904 ...	Victoria Cross, G.M.L. 5131z ...	32'00	7'48	'23
	Total ...	119'00	203'25	1'70

**The Warrior, G.M.L. 3048z.** — This lease was worked and owned by the Warrior Menzies G.M. Co., N.L. (late Wallaroo Menzies G.M. Co., N.L.), which Company also owned the Gem, G.M.L. 3235z, and the Monte Christo Battery, on G.M.L. 3398z.

There are three lines of lode upon this property, called respectively the main lode and the eastern and western.

The main lode was first opened upon by an underlay shaft 115 feet deep, from the bottom of which a level was driven 280 feet south, the lode being about four feet in thickness. [751, 755, 6371.]

A main vertical shaft was sunk about 200 feet to the westward of the underlay shaft to a depth of 200 feet without cutting water. At 100 feet from the surface a crosscut was driven east 130 feet, which cut the level 100 feet south of the underlay shaft. From this level a winze was put down 60 feet at a point 50 feet south of the crosscut.

At the 200 feet level a crosscut has been driven 75 feet east, which cut the lode, the latter being driven on for a distance of 70 feet south. A winze was sunk from this level at a point 10 feet south of the crosscut to a depth of 30 feet, the stone being about four feet six inches thick.

On the western lode there are three shafts—a vertical 110 feet, one underlay 80 feet, and one 115 feet with 272 feet of drives. Most of the work has been confined to the upper levels, where the lode was from two feet to two feet six inches in thickness, but a little has been done at 110 feet, where it is three feet six inches thick.

On the eastern reef an underlay shaft has been sunk 75 feet and a level driven 90 feet, in which the stone is three feet in thickness. Another shaft has been sunk on the line of this lode to cut it at 129 feet, but it is only down 90 feet at present.

A considerable amount of stoping has been done from the various levels, whilst the quantity of stone raised and crushed is given in the following table:—

*Table showing the Yield of the Warrior Reefs.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1898 ...	Warrior Menzies, G.M.L. 3048z ...	200·00	184·89	·92
1899 ...	Do. " ...	212·00	119·48	·56
1900 ...	Do. " ...	298·00	200·88	·67
1901 ...	Do. " ...	340·00	161·73	·47
1902 ...	Do. " ...	80·00	39·13	·48
1903 ...	Do. " ...	23·00	22·95	·99
1903 ...	Warrior, G.M.L. 3048z ...	205·00	205·21	1·00
1904 ...	Do. " ...	344·00	172·26	·50
1905 ...	Do. " ...	101·00	41·02	·40
Total ...		1,803·00	1,147·55	·64

The Indus, G.M.L. 4291z; Opal, G.M.L. 5100z; Battlers' Rest, G.M.L. 5143z; and Lucky Prop, G.M.L. 5127z, were small leases situated to the south of the Warrior, upon which a little work was done.

*Table showing the Yield of the above-mentioned Leases.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1899 ...	Indus, G.M.L. 4291z ... ..	16·00	2·76	·17
1904 ...	Opal, G.M.L. 5100z ... ..	30·00	4·71	·15
1903 ...	Battlers' Rest, G.M.L. 5143z ... ..	10·00	12·97	1·29
1904 ...	Do. „ ... ..	11·00	5·06	·46
	Total ... ..	67·00	25·50	·38
1903 ...	Lucky Prop, G.M.L. 5127z ... ..	72·00	17·98	·24

**The Lady Harriet Leases, G.M.Ls. 4972z and 5003z.**—This area was owned by the Menzies Pioneers, Ltd., which Company held it until 1898, since which time it has been owned locally.

At one time there appears to have been a considerable amount of dryblowing carried on upon this lease, whilst to the westward a large number of shafts have been sunk, apparently upon an alluvial lead, but no record appears to exist with regard to the quantity of gold obtained.

The original Company did a very considerable amount of shaft-sinking, driving, and crosscutting on this property upon a line of lode which strikes about 35 degrees west of north, and dipping to the southward at varying angles, though usually steep. The ore occurred in pipes or shoots, and is pretty well worked out in the upper levels.

The deepest shaft is 200 feet, and in this salt water was struck at a depth of 160 feet (the water level is now 188 feet).

Recently the Lady Shenton Gold Mines, Ltd., took an option on this property when, according to the manager's report, a large quantity of sinking, driving, and crosscutting was done below the existing workings. In summing up the situation, Mr. Falconer, the manager, says:—"Payable stone had been crushed, and was then showing in four different shoots. The shoot at No. 1 shaft has



been proved to be non-existent at the 187 feet level over a length of 229 feet. The shoot in the No. 2 shaft has been proved to have a total length of 110 feet at the 40 feet level, and 26 feet at the 100 feet level, and an average value of 10dwts. The shoot in No. 3 shaft has not been completely explored, but, judging from the work already done, is very probably only a short pipe. The shoot in No. 4 shaft has been proved at the 187 feet level to have a length of 20 feet, a width of five feet, and an average value of 30dwts." \*

Even at the moderate depth of 187 feet, where most of this work was carried out, the country was so hard as to necessitate the use of rock drills. It will be seen from the above that the lodes here are of a similar character to those further north, *i.e.*, rich pipes of ore which decrease in size and die out as they approach the hard country.

At the south-east end of this line of reef, a cross reef from the outcrop of which the dryblowing patch starts; this latter has been worked both in this lease and in that adjoining, called the Olivia, from which it is named. The reef strikes in a north-easterly direction, and dips to the north-west; its junction with the Harriet Reef in all probability feed the alluvial patch.

*Table showing the Yield of the Lady Harriet Reefs.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
					Ore crushed.	Gold therefrom.	
		tons.	ozs.	ozs.	tons.	ozs.	ozs.
1897 ...	Lady Harriet, G.M.L. 2822z (Menzies Pioneers, Ltd.)	613'00	689'40	1'12			
1898 ..	Do.	...	28'43	...	613'00	717'83	1'17
1899 ...	Lady Harriet, G.M.L. 2822z	334'00	230'74	'84			
1900 ..	Do.	425'00	364'71	'85	759'00	645'45	0'88
1901 ...	Lady Harriet, G.M.L. 4972z	320'00	241'98	'75			
1902 ...	Do.	295'00	472'75	1'60			
1903 ..	Do.	113'00	405'85	3'62			
1904 ...	Do.	631'00	474'09	'75			
1905 ...	Do.	819'00	488'71	'59	2,177'00	2,063'38	'95
	Total	...	...	...	3,549'00	3,446'66	'97

\* Report to the directors of the Lady Shenton Gold Mine, Limited.

To the south of the Lady Harriet there are several small properties upon which a little work has been done, which have yielded the following returns:—

*Table showing the Yield of the Reefs south of the Lady Harriet.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1898 ...	Ourine, G.M.L. 4877z ...	33·00	22·83	·76
1898 ...	Jimgellie, G.M.L. 4877z ...	42·00	28·78	·68
1898 ...	Three Battlers, G.M.L. 4871z ...	57·00	40·09	·72
1902 ...	Coronation Gift, G.M.L. 5064z ...	29·00	22·25	·77
	Total ...	86·00	62·34	·72
1901 ...	Home Signal, G.M.L. 4993z ...	5·00	4·94	·98
1903 ...	Great Hope, G.M.L. 5090z ...	12·50	21·85	1·74
	Total ...	17·50	26·79	1·52
1897 ...	Daisy Bell, G.M.L. 4061z ...	49·00	47·11	·96
1898 ...	Do. " ...	23·00	22·23	·96
1903 ...	Bellinger, G.M.L. 5114z ...	2·00	·28	·14
1904 ...	Do. " ...	29·00	8·74	·30
	Total ...	103·00	78·36	·76
1898 ...	Ancient Britain Extended, G.M.L. 4007z	26·00	20·79	·78

The Maori Chief, G.M.L. 4987z ; the Sefton, G.M.L. 5080z, or Double Event, G.M.L. 5135z ; and the Eureka, G.M.L. 5078z, are situated upon the eastern side of the Railway Line to the eastward of the Golden Age, G.M.L. 2830z.

Little has been done on these, with the exception of the Maori Chief, G.M.L. 4987z, the workings on which consist of a main shaft 96 feet deep, from which a crosscut has been driven at the 70 feet level 33 feet east to a level which is 110 feet long, which is also connected with the surface by a vertical and an underlay shaft.

The ore-shoot, which dips south, and is about 18 inches wide has been driven upon for 65 feet in the southern portion of this level ; it has been worked up to the surface and is now being followed down by the means of winzes.

Table showing the Yield of the Maori Chief and other Reefs.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	oss.	oss.
1899 ...	Maori Chief, G.M.L. 4914z ... ..	7·00	9·27	1·32
1900 ...	Do. " " " " " " " " " "	296·00	209·14	·73
1901 ...	Do. 4987z " " " " " " " " " "	90·00	44·90	·49
1902 ...	Do. " " " " " " " " " "	74·00	88·61	1·19
1903 ...	Do. " " " " " " " " " "	...	...	...
1904 ...	Do. " " " " " " " " " "	96·00	74·28	·74
1905 ...	Do. " " " " " " " " " "	283·00	266·99	·94
	Total ... ..	543·00	474·68	·87
1903 ...	Sefton, G.M.L. 5060z ... ..	8·10	12·66	1·56
1904 ...	Double Event, G.M.L. 5135z ... ..	36·00	44·15	1·22
1905 ...	Do. " " " " " " " " " "	38·00	17·05	·34
	Total ... ..	82·10	73·86	·89

The **Menzies Lady Mary**, G.M.L. 3121z, lies a few chains to the eastward of the last, and from it 14 tons of stone were crushed in 1897, which yielded only 1·22 ounces of gold. The balance of the stone, which is of a ferruginous character, is still at grass. [792, 793, 798.]

#### Miscellaneous Leases.

Upon the western side of the Railway Line, and running towards it and eventually crossing it, is a line of scattered leases upon which a considerable amount of development work was done in places by Companies during the boom time, but since their abandonment they have been worked by prospectors in a desultory manner.

This line starts at the northern end with the **OLIVE BRANCH**, G.M.L. 5112z, which is situated upon the side of an immense barren quartz blow, forming a portion of the dividing ridge between the northern and south-western watershed. South of this lie the two leases, both named the **LINCOLN**, G.M.Ls. 5134z, 5181z; then the **LADY SARAH**, G.M.L. 5009z, afterwards called the **LADY FANNY**, G.M.L. 5179z; then the **QUEENSLANDER**, G.M.L. 5126z; and **TWO WALTERS**, G.M.L. 5207z.

Next, upon a steep laterite hill to the east of the **LADY HARRIET**, G.M.L. 4972z, are the old leases formerly known as the **MONTÉ CRISTO**, G.M.L. 3398z; and **GEM**, G.M.L. 3235z, which were owned by the **Warrior Menzies Company** (late Wallaroo). This Company did a considerable amount of work upon them, but, apparently, did not succeed in discovering a payable lode. A battery was, however, erected on the ground, and a water supply obtained by sinking, the stone crushed coming from the **Warrior**, G.M.L. 3048z.

These leases have since been held as the **SAILOR**, G.M.L. 5109z; **BRISTOL**, G.M.L. 5116z; **BUSY BEE**, G.M.L. 5105z; and **ADELAIDE**, G.M.L. 5128z; but have, apparently, never yielded rich stone. On

the GEM EXTENDED, G.M.L. 4957z, now the MENZIES STAR, G.M.L. 5118z, a number of shafts have been sunk upon a vein of the usual type, which has been worked in the oxidised zone since 1897 by various parties.

South of this, again, are the LUCKY VENTURE, G.M.L. 5151z, and LORD NELSON, G.M.L. 5111z; and to the south-west of these the KLONDYKE, G.M.L. 5226z; the GREAT KLONDYKE, G.M.L. 4853z; the BRITANNIA, G.M.L. 4850z; the HOENET'S NEST, G.M.L. 4998z; and the GOLDEN HORSESHOE, G.M.L. 4990z; whilst to the eastward of the railway line are the LUCKY HIT, G.M.L. 5137z, or LUCKY STRIKE, G.M.L. 5194z; the NEVER DESPAIR, G.M.L. 5225z; the BALLARAT MENZIES, G.M.L. 5113z; the JUST-IN-TIME, G.M.L. 4886z; the SOPHIA, G.M.L. 5238z; the BLACK AND WHITE, G.M.L. 4978z; the GUIDING STAR, G.M.L. 4951z; and the COLUMBIA, G.M.L. 5104z.

*Table showing the Yield of Miscellaneous Leases.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1904 ...	Olive Branch, G.M.L. 5112z ...	40'00	8'29	'20
1904 ...	Lincoln, G.M.L. 5134z ...	31'00	71'75	'231
1904 ...	Lincoln, G.M.L. 5181z ...	37'00	59'17	1'54
1905 ...	Do. " ...	24'00	47'25	2'71
	Total ...	61'00	106'42	1'74
1901 ...	Lady Sarah, G.M.L. 5009z ...	40'00	48'17	1'20
1902 ...	Do. " ...	60'00	74'34	1'23
1903 ...	Do. " ...	38'00	5'46	'14
1904 ...	Lady Fanny, G.M.L. 5179z ...	16'00	10'09	'63
	Total ...	154'00	138'06	'89
1903 ...	Queenslander, G.M.L. 5126z ...	28'00	16'10	'57
1904 ...	Do. " ...	8'00	4'25	'53
	Total ...	36'00	20'35	'56
1904 ...	Two Walters, G.M.L. 5207z ...	30'00	10'78	'35
1905 ...	Do. " ...	50'00	20'00	'40
	Total ...	80'00	30'78	'38
1897 ...	Monte Christo and Gem, G.M.Ls. 8235z, 3398z	12'00	2'42	'20
1903 ...	Sailor, G.M.L. 5109z ...	...	59	...
1903 ...	Bristol, G.M.L. 5116z ...	12'00	4'64	'38
1904 ...	Do. " ...	14'00	3'06	'22
1903 ...	Busy Bee, G.M.L. 5105z ...	48'00	20'87	'45
1904 ...	Do. " ...	161'00	59'00	'37
1904 ...	Adelaide, G.M.L. 5128z ...	109'00	52'02	'47
	Total ...	354'50	143'50	'40

Table showing the Yield of Miscellaneous Leases—continued.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1897 ...	Gem Extended, G.M.L. 4849z ...	52 00	25 96	49
1898 ...	Do. do. " ...	52 00	21 08	40
1899 ...	Do. do. " ...	19 50	8 14	42
1900 ...	Do. do. 4957z ...	15 00	6 33	42
1902 ...	Do. do. 5015z ...	15 00	6 92	46
1904 ...	Menzies Star, G.M.L. 5118z ...	94 00	55 68	59
1905 ...	Do. do. " ...	20 00	6 41	32
	Total ...	267 50	130 51	49
1904 ...	Lucky Venture, G.M.L. 5151z ...	45 00	9 49	21
1902 ...	Lord Nelson, G.M.L. 5021z ...	12 00	4 55	37
1897 ...	Great Klondyke, G.M.L. 4853z ...	16 80	36 94	2 20
1903 ...	Klondyke, G.M.L. 5132z ...	16 00	6 33	39
1904 ...	Do. " ...	15 00	2 04	13
1905 ...	Do. " ...	52 00	11 72	22
	Total ...	83 00	20 09	24
1898 ...	Britannia, G.M.L. 4850z ...	8 00	2 74	34
1901 ...	Hornet's Nest, G.M.L. 4998z ...	5 00	1 08	33
1901 ...	Golden Horseshoe, G.M.L. 4990z ...	20 00	7 31	36
1903 ...	Lucky Hit, G.M.L. 5137z ...	5 00	9 75	1 95
1904 ...	Do. " ...	35 00	5 49	15
1904 ...	Lucky Strike, G.M.L. 5194z ...	36 00	5 10	14
	Total ...	76 00	20 34	26
1905 ...	Never Despair, G.M.L. 5225z ...	81 00	42 10	50
1898 ...	Just in Time, G.M.L. 4886z ...	24 00	12 04	50
1903 ...	Ballarat Menzies, G.M.L. 5113z ...	25 75	12 22	47
1904 ...	Do. " ...	39 00	5 84	15
1904 ...	Just in Time, G.M.L. 5141z ...	25 00	4 08	62
	Total ...	113 75	34 18	30
1905 ...	Sophia, G.M.L. 5233z ...	113 00	79 34	70
1901 ...	Black and White, G.M.L. 4978z ...	62 00	26 56	44
1902 ...	Do. " ...	20 00	9 00	45
	Total ...	82 00	35 56	43
1900 ...	Guiding Star, G.M.L. 4951z ...	48 00	33 74	70
1901 ...	Do. " ...	200 35	220 92	1 11
1902 ...	Do. " ...	23 00	13 60	59
1904 ...	Columbia, G.M.L. 5104 ...	18 00	9 86	55
	Total ...	289 35	278 12	93

The **CRAIG-Y-NOS**, G.M.L. 5250, is situated upon the eastern side of the Railway Line and north of the township of Woolgar; it has repeatedly changed hands, but in no instance has it been held for long.

A considerable amount of developmental work was done upon it by the W.A. Venture Corporation, who held it in 1897, and who sank two shafts—one 100 feet, and one 150 feet—with 500 feet of drives. Owing to the fact that it has so often changed hands, no systematic work has been carried out, and in consequence no opinion as to the character of the lode can be formed.

*Table showing the Yield of the Craig-y-nos Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
					Ore crushed.	Gold therefrom.	
1897	Sick of Time, G.M.L. 3205z	tons. 177.50	ozs. 113.17	ozs. '63	tons. 117.50	ozs. 113.17	ozs. '63
1898	Athelstane, G.M.L. 4873z	362.00	171.77	'47			
1899	Do.	96.00	32.73	'34	458.00	204.50	'45
1900	Craig-y-nos, G.M.L. 4940z	318.00	244.61	'83			
1901	Do.	208.75	85.30	'40	527.25	349.91	'66
1902	Perseverance, G.M.L. 5102z	98.00	29.52	'30	98.00	29.52	'30
1903	Craig-y-nos, G.M.L. 5220z	220.00	88.15	'40	220.00	88.15	'40
	Total ...	...	...	...	1,480.75	785.25	'53

**THE MENZIES GIFT**, G.M.L. 3036z, and **THE GIFT**, G.M.L. 4916z, which adjoins it, are situated a little south of Woolgar, and mining was evidently started here on the strength of their position at the head of an alluvial run which extended from them to a little beyond the Telegraph line in a westerly direction. Of the latter there are no records nor returns, whilst the reefs worked proved of too low a grade to be payable. From the former of these 50.00 tons of stone were crushed, which yielded 12.74ozs. of gold, and from the latter 10.00 tons, which yielded 5.37ozs. of gold.

**THE BARUNGA BRAVE**, G.M.L. 4691z, is situated about  $2\frac{1}{2}$  miles south. It has not been worked since 1898, up to which date 23 tons of stone were crushed, which yielded 19.72ozs. of gold [1185, 1189].

**THE BLACK HORSE**, G.M.L. 5106z, and **STORM KING**, G.M.L. 5176z, are situated upon a low ridge about one mile to the eastward of Woolgar. A small patch of alluvium was worked in a little gully crossing the former, which terminated at a small quartz vein which is now being worked.

*Table showing the Yield of the Black Horse Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	per
		tons.	ozs.	
1903 ...	Black Horse, G.M.L. 5106z ...	...	22·79	
1904 ...	Do. ...	140·00	181·81	
1905 ...	Do. ...	78·00	45·71	
	Total ...	216·00	250·31	

THE BLACK JACK, G.M.L. 4879z, is situated to the south of the last, being a portion of what was originally the Lady N and upon it four shafts have been sunk, the deepest being 187 in which the water level is 170 feet from the surface. The varied from eight inches to three feet in width with six to eight of formation. The course of the shoot, which was 100 feet wide little west of north with a southerly dip, but it dies out below 130-foot level. The vein is of the lenticular type, and decrease size and value with depth.

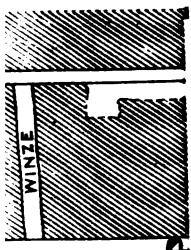
*Table showing the Yield of the Black Jack Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Re per
		tons.	ozs.	of
1897 ...	Lady Main, G.M.L. 3963z ...	95·00	112·65	1·1
1898 ...	Black Jack, G.M.L. 4879z ...	50·00	94·79	1·6
1899 ...	Do. ...	190·00	314·42	1·6
1900 ...	Do. ...	306·00	470·00	1·5
1901 ...	Do. ...	113·00	99·64	·8
1902 ...	Do. ...	120·00	62·74	·5
1903 ...	Do. ...	10·00	9·60	·9
1904 ...	Do. ...	150·00	35·60	·2
1905 ...	Do. ...	12·00	9·28	·7
	Total ...	1,056·00	1,209·18	1·1

THE LONE HAND, G.M.L. 5230z, lies a little west of the latter and from it 37 tons of stone yielded 34·47 ounces of gold.

THE MENZIES CONSOLIDATED GOLD MINE, LTD.—This Company own a number of leases situated upon the western side of the railway line close to the township of Woolgar.

The main workings are situated upon the Princess May South G.M.L. 4935z, but extend northward into the Princess May, G.M.L. 4934z. The line of reef, however, has been traced in a north west direction for over 1,000 feet into the Princess Eva, G.M.L. 981z, where another series of old workings are located. On the





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Princess May South, a main shaft has been sunk to a depth of 425 feet, which cuts the reef between the No. 1 and No. 2 levels, below which crosscuts connect it with the various levels, the No. 5 level at the bottom being 170 feet distant. Owing to the distance from the lode being so great, the shaft was not continued, but a main haulage winze carried down from the No. 5 at a point about 100 feet further south, by means of which the mine was worked to the No. 9 or 688-foot level, but since the ore-shoot had dipped to the southward of this, another winze has been sunk still further south from the bottom level, which has now reached a vertical depth below the surface of over 800 feet; this is therefore considerably the deepest mine in Menzies. (Plate VI.)

The ore in this mine has proved in the nine levels to average about 400 feet in horizontal length with a dip of about 36 degrees south upon the plane of the lode, which dips 57 degrees south-west, the total length of the proved ore-shoot from the surface to the bottom of the mine being over 1,600 feet, whilst the thickness is so variable that it is impossible to state it but it must average three feet.

The lode is clearly of the true fissure type having an extremely well-defined and striated footwall, whilst the hanging wall is more or less broken by feeders. In the levels above No. 6 a parallel lode has been worked which had a strike more to the westward, this, however, took a turn between Nos. 5 and 6 more to the northward than the main ore body with which it would appear to junction further north. The main ore-shoot in this mine appears if anything to gain in width and definition with depth, whilst in the north drive at the No. 9 level, the vein was found to continue and carry gold for a distance of over 800 feet, it being poor near the winze but improves towards the end. This may be another shoot or the continuation of one that was prospected at the surface farther north.

At the bottom of the winze the lode is highly mineralised, carrying large quantities of Pyrrhotite (magnetic pyrites) [6314] whilst the gold value still keeps up, the vein being over six feet in thickness and as well defined as at any part of the mine.

In the northern workings upon the Princess Eva a main shaft has been sunk and the lode worked to a depth of over 200 feet, but owing to very considerable faulting these workings were abandoned and the shaft is now used as a water shaft.

Water containing 2.8 per cent. of solid matter was cut at a depth of 130 feet, which yielded originally 30,000 gallons per diem this, however, has considerably diminished whilst after passing through the zone of saturation, the formation is practically dry. [1647-52.]

Table showing the Yield of the Menzies Consolidated Reef.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1897 ...	Princess May and Princess May South, G.M.Ls. 4934z and 4935z ...	6,525·0	5,456·13	·83
1898 ...	Do. do. ...	6,969·0	5,702·80	·82
1899 ..	Do. do. ...	7,617·0	6,978·04	·92
1900 ...	Do. do. ...	6,589·0	5,936·89	·90
1901 ...	Do. do. ...	10,489·0	6,817·49	·65
1902 ...	Do. do. ...	12,795·0	7,535·36	·59
1903 ...	Do. do. ...	16,096·0	8,341·31	·52
1904 ...	Do. do. ...	14,657·0	8,972·58	·61
1905 ...	Do. do. ...	17,834·0	10,134·44	·59
	Total ... ..	99,371·0	65,875·05	·66

The GOODENOUGH, G.M.L. 4855z, is situated about three miles in an east-north-east direction from Menzies, and lies at the extreme north of the Kensington Group; it has recently been acquired by the Queensland Menzies G.M. Co., N.L.

A line of lode can be traced at the surface in an east and west direction for a distance of about 600 feet lying parallel to an out-crop of sericite schist, which is apparently a dyke, whilst to the south it dips into a solid diorite hill. [6337, 6340, 6364.]

Five underlay shafts, the deepest of which is 240 feet, have been sunk upon this lode, which dips at an angle of from 25 to 30 degrees south. Levels have been driven at the 100 feet (55 feet vertically below the surface) and 180 feet (80 feet vertical depth, or at the water-level) upon a body of stone varying from three to six feet in thickness. A dislocation in the lode was met with in the 100-feet level a little north of the No. 2 shaft, beyond which a branch vein appears to have been followed. The main lode however was picked up to the northward and opened upon near the mouth of the No. 1 shaft by means of first an opencut and then a winze which was carried down to the 100-feet level.

In the opencut the reef is large and solid, and yielded very good returns, but suddenly came to an end upon what is probably a fault; but it is too near the surface to determine this point with any degree of certainty.

This lode is very highly ferruginous in places, being literally one mass of pyrites, whilst specimens of chloride of silver have also been met with.

All the developments so far have been carried on in the oxidised zone, where the rock is soft and of a yellow argillaceous nature; in consequence it affords little evidence as to its original character. So far the stone crushed has been of good quality, but the gold is of very low value.

There is a good supply of fresh water in a well a little north of the outcrop said to have yielded 2,000 gallons per diem, whilst the water in the mine makes at the rate of about 600 gallons.

*Table showing the Yield of the Goodenough Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1897 ...	Goodenough, G.M.L. 4855z ...	125·00	104·82	·83
1898 ...	Do. " ...	167·50	264·11	1·57
1899 ...	Do. " ...	390·55	564·34	1·44
1900 ...	Do. " ...	322·50	380·05	1·17
1901 ...	Do. " ...	852·40	1,314·33	1·55
1902 ...	Do. " ...	694·00	1,671·57	2·40
1903 ...	Do. " ...	518·00	603·05	1·16
1904 ...	Do. " ...	361·00	276·09	·76
1905 ...	Do. " ...	1,017·00	1,042·80	1·02
	Total ...	4,447·85	6,220·66	1·39

To the eastward and southward of the Goodenough are the following leases, upon which little work has been done:—

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1898 ...	Golden Shoe, G.M.L. 4861z ...	44·00	51·36	1·17
1902 ...	Coronation, G.M.L. 5041z ...	10·00	8·39	·84
1905 ...	Little Vic or Anti Daglish, G.M.L. 5225z	17·50	29·73	1·70

#### Miscellaneous Leases.

On the **FOUR O'CLOCK**, G.M.L. 5072z, which lies to the south-west, a small reef with a north-east south-west course and dipping south-east has been worked to a shallow depth for a length of five chains, whilst on the **RESURGAM**, G.M.L. 5117z, which apparently lies upon the same line, the reef has been traced for a length of

10 chains but has only been worked for a length of 80 feet and to a depth of 30 feet, the average size being three inches.

*Table showing the Yield of the Four o'Clock and Resurgam Reefs.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons	ozs.	ozs.
1901 ...	Four o'Clock, G.M.L. 5012z ...	10'00	10'90	1'09
1902 ...	Do. " ...	45'00	20'41	'45
1902 ...	Do. 5072z ...	18'00	20'23	1'12
1903 ...	Do. " ...	35'00	45'71	1'30
1904 ...	Do. " ...	20'00	4'00	'20
	Total ...	128'00	101'25	'79

1902 ...	Resurgam, G.M.L. 5076z ...	10'00	9'02	'90
1903 ...	Do. " ...	11'00	20'67	1'88
1903 ...	Do. 5117z ...	10'00	4'68	'46
1904 ...	Do. " ...	5'00	4'74	'95
	Total ...	36'00	39'11	1'09

To the eastward of the last and south of the Goodenough are BROWN HILL, G.M.L. 4949z, the RISING SUN, G.M.L. 5040z, and CHRISTMAS GIFT, G.M.L. 5016z; whilst the DANAÆ, G.M.L. 5050z, and BLAAS REWARD, G.M.L. 5025z, lie to the south-west on the flat, and the INDUSTRIA, G.M.L. 4899z, south along the range.

*Table showing the Yield of Miscellaneous Leases.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1900 ...	Brown Hill, G.M.L. 4049z ...	15'00	9'19	'57
1901 ..	Do. " ...	16'00	5'72	'39
	Total ...	31'00	14'91	'48
1902 ...	Rising Sun, G.M.L. 5040z ...	10'00	10'03	1'00
1902 ...	Christmas Gift, G.M.L. 5016z ...	93'00	83'88	'90
1902 ...	Blaas Reward, G.M.L. 5025z . .	23'00	17'64	'77
1902 ...	Danae, G.M.L. 5050z ...	10'00	3'89	'38
1899 ...	Industria, G.M.L. 4899z ...	44'80	14'94	'34

The TRUE BLUE, G.M.L. 3822z, now known as the Picton, G.M.L. 4985z, was worked from 1899 to 1901 by the W.A. Proprietary Company, who in sinking a main shaft struck a supply of 1,300 gallons per diem of fresh water at a time when water was particularly scarce in Menzies. Several shafts have been sunk upon this property in which a large low-grade formation was cut which strikes in a north-east and south-west direction, dipping at a low angle to the south-east, but of this only the quartz-veins in the upper levels have been worked.

*Table showing the Yield of the Picton Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1899 ...	True Blue, G.M.L. 3822z ...	100.00	24.05	.24
1901 ...	Do. ...	56.00	14.59	.26
1901 ...	Picton, G.M.L. 4985z ...	50.00	19.94	.40
1904 ...	Do. ...	177.50	51.61	.40
1905 ...	Do. ...	143.00	27.52	.19
	Total ...	526.50	137.71	.26

Between the Picton and the Kensington there have been a number of leases which have been worked upon a series of lenticular quartz-veins which strike north-east and dip south-east. These start with the True Blue South, G.M.L. 4923z, which later on was called the Lord Roberts, G.M.L. 5168z, in which a body of stone four feet wide was worked for a length of 200 feet and to a depth of from 40 to 50 feet.

*Table showing the Yield of the True Blue South Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1899 ...	True Blue South, G.M.L. 4923z ...	44.00	22.48	.51
1900 ...	Do. ...	7.00	31.93	4.56
1901 ...	Lord Roberts, G.M.L. 5007z ...	39.00	27.40	.70
1902 ...	Do. ...	30.00	10.69	.35
1903 ...	Do. 5168z ...	26.00	7.06	.27
	Total ...	146.00	99.56	.68

The KENSINGTON VINDICATOR, G.M.L. 3615z, was originally worked as a whole by a Company, but later the northern portion was taken up as the Alexandra, G.M.L. 4918z, and later on as the

Butterfly, G.M.L. 4992z. On this ground a lode has been worked for a length of 200 feet, the quartz averaging about 12 inches down to the 50-foot level. A shaft has been sunk to a depth of 135 feet, which cut a supply of stock water yielding about 50 gallons per diem.

*Table showing the Yield of the Butterfly Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1898 ...	Kensington Vindicator, G.M.L. 3615z	26'00	45'60	1'75
1899 ...	Do. " "	7'00	2'10	'30
1899 ...	Alexandra, G.M.L. 4918z ...	15'00	19'24	1'28
1900 ...	Do. " " " "	82'00	136'52	1'90
1901 ...	Do. " " " "	6'00	16'13	2'69
1901 ...	Butterfly, G.M.L. 4992z ...	25'00	54'96	2'19
1902 ...	Do. " " " "	33'00	72'07	2'19
1903 ...	Do. " " " "	16'00	29'24	1'82
1904 ...	Do. " " " "	23'50	10'93	'47
	Total ...	2'3'50	386'79	1'65

Upon the southern portion of this, which was afterwards called the VINDICATOR SOUTH, G.M.L. 4924z, and later the LITTLE TOM, G.M.L. 5083z, a small vein of stone about 8 inches wide has been opened up to a depth of 60 feet. This vein on its southward course gradually loses its easterly dip, turning flat with a slight southerly dip, then tilting over to the west.

*Table showing the Yield of the Little Tom Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1899 ...	Vindicator South, G.M.L. 4924z ...	9'00	7'56	'84
1900 ...	Do. " " " "	20'00	25'27	1'26
1902 ...	Little Tom, G.M.L. 5083z ...	7'00	12'51	1'79
1903 ...	Do. " " " "	18'00	27'98	1'55
	Total ...	54'00	73'32	1'35

Upon the MENZIES KENSINGTON, G.M.L. 3277z, which adjoins the last, to judge from the large cavern-like excavation a large lenticular body of quartz with a southerly dip was worked, the extension of which has not been cut in any of the shafts either to the dip or on the strike. A number of vertical shafts have been

sunk, one 125 feet (which is the water-level), and another 100 feet, whilst an underlay has been sunk 70 feet and 400 feet of driving, but in these no stone of any value was cut.

*Table showing the Yield of the Kensington Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1897 ...	Menzies Kensington, G.M.L. 3277z ...	466'00	408'97	'87
1898 ...	Do. " ...	327'00	217'68	'66
1899 ...	Do. " ...	135'00	133'06	'98
1900 ...	Do. " ...	..	23'32	...
1901 ...	Kensington, G.M.L. 3277z ...	33'00	83'99	2'54
1902 ...	Do. " ...	...	...	...
1903 ...	Do. " ...	102'00	21'20	'21
1904 ...	Do. " ...	10'00	5'19	'51
	Total ...	145'00	110'38	'83

The TRUE BLUE, G.M.L. 5130z, is situated a little to the eastward of the Kensington line and south of the Picton, and in it a small vein of rich quartz has been traced for a length of 400 feet at a depth of 40 feet from the surface.

*Table showing the Yield from the True Blue Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1903 ...	True Blue, G.M.L. 5130z ...	22'00	42'02	1'21
1904 ...	Do. " ...	57'00	128'40	2'25
1905 ...	Do. " ...	18'00	16'35	'90
	Total ...	97'00	186'77	1'92

Farther east still upon the western side of Mt. Misery are two old leases which have covered the same ground called respectively the PICTON VALLEY, G.M.L. 4890z, and the LADY MIN, G.M.L. 4917z. The reef is small but well defined, striking north-east and dipping south-east, and can be traced into the Maranora, which appears to be the southern extension of it.

The workings consist of two groups of shallow underlay shafts in which apparently some 3 or 4 inches of the hanging-wall side has been worked to a depth of 20 feet.



*Table showing the Yield of the Lady Min Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons	ozs.	ozs.
1898 ...	Picton Valley, G.M.L. 4890z ...	10'00	21'51	2'15
1899 ...	Do. ...	10'00	14'31	1'43
1899 ...	Lady Min, G.M.L. 4917z ...	5'00	9'91	1'98
1900 ...	Do. ...	10'00	46'37	4'63
	Total ...	35'00	92'10	2'63

THE OLD HIDDEN TREASURE, G.M.L. 4750z, is now being worked as the MARANORA, G.M.L. 4895z, and in it a reef dipping at an angle of 80 degrees south-east which, varying from a few inches to seven feet in thickness, has been opened up to a depth of 140 feet by a level 300 feet in length, the course of which is 21 degrees east of north. The shaft has been continued to a depth of 198 feet, a small supply of stock water being cut at 150 feet.

The reef is enclosed in a formation carrying a little gold, the thickness of which has not yet been tested.

The character of this reef cannot be determined at the only level accessible, but it presents many indications of being of the fissure type; this is further supported by its length of outcrop [1053].

*Table showing the Yield of the Maranora Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1898 ...	Hidden Treasure, G.M.L. 4750z ...	10'00	5'20	·52
1899 ...	Maranora, G.M.L. 4895z ...	278'30	281'65	1'01
1900 ...	Do. ...	307'00	402'30	1'31
1901 ...	Do. ...	223'00	216'50	·97
1902 ...	Do. ...	215'00	226'04	1'05
1903 ...	Do. ...	272'00	292'63	1'07
1904 ...	Do. ...	286'00	236'25	·83
1905 ...	Do. ...	454'00	479'78	1'17
	Total ...	2,035'50	2,135'15	1'04

To the southward of the last are a group of old leases which have covered more or less the same ground; these consist of the KENSINGTON EASTER GIFT, G.M.L. 5103z, PRINCE ALBERT, G.M.L. 4926z, WEST SEA, G.M.L. 4908z, and MOONLIGHT, G.M.L. 5183z. On these a small reef, from five to six inches in width, dipping to the westward, has been opened up to a depth of 60 feet and worked for a length of five chains.

*Table showing the Yield from sundry Leases.*

Year.	Name and Number of Leases.	Ore crushed.	Gold therefrom.	Rate per ton.
1903 ...	Kensington Easter Gift, G.M.L. 5103z	tons. 13'00	ozs. 19'97	ozs. 1'46
1904 ...	Do. " "	4'00	3'45	'86
	Total ... ..	17'00	23'42	1'38
1899 ...	West Sea, G.M.L. 4908z ... ..	12'00	7'43	'62
1899 ...	Prince Albert, G.M.L. 4926z ... ..	6'00	4'91	'82
1900 ...	Do. " " ... ..	15'00	6'43	'43
1904 ...	Moonlight, G.M.L. 5183z ... ..	35'00	25'71	'73
	Total ... ..	68'00	44'48	'65

To the eastward of the last, another line has been worked as the **BRILLIANT**, G.M.L. 5184z, the **KENSINGTON SUNDAY GIFT**, G.M.L. 4819z, or **SUNDAY GIFT**, G.M.L. 5010z, and the **MENZIES LUXEMBERG**, G.M.L. 5043z. The reef here strikes north and south and dips west, being two to six feet thick in the Brilliant; on the Sunday Gift it has been sunk on to a depth of 80 feet, and is about 12 inches in thickness, whilst in the Luxemburg the stone is small, but it has been worked for a length of 100 feet, to a depth of 40 feet, where the hard rock comes in. This vein at its north end is very flat, but generally dips steeper towards the south end.

*Table showing the Yield of sundry Leases.*

Year.	Name and Number of Leases.	Ore crushed.	Gold therefrom.	Rate per ton.
1899 ...	Brilliant, G.M.L. 4911z ... ..	tons. 13'00	ozs. 8'45	ozs. '65
1904 ...	Brilliant, G.M.L. 5184z ... ..	12'00	3'41	'28
1906 ...	Do. " " ... ..	14'00	2'20	'16
	Total ... ..	39'00	14'06	'38
1896 ...	Kensington Sunday Gift, G.M.L. 4819z	26'00	27'81	1'07
1901 ...	Sunday Gift, G.M.L. 5010z ... ..	16'00	50'64	3'16
1902 ...	Do. " " ... ..	72'30	197'59	2'74
1903 ...	Do. " " ... ..	57'00	140'55	2'46
1904 ...	Do. " " ... ..	68'00	65'59	'96
1905 ...	Do. " " ... ..	88'00	89'32	1'02
	Total ... ..	353'00	599'31	1'79
1902 ...	Menzies Luxemburg, G.M.L. 5043z ...	6'00	5'02	'83

**THE VIKING**, G.M.L. 5038z, is a line further east still, and upon it a vein of stone, which runs in pipes varying from six to 12 inches

in thickness, has been worked for a length of 200 feet, the deepest shaft being 70 feet.

*Table showing the Yield of the Viking Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1902 ...	Viking, G.M.L. 5038z ... ..	30'00	137'59	4'58
1903 ...	Do. " ... ..	21'00	81'36	3'87
1904 ...	Do. " ... ..	18'00	112'05	6'22
1905 ...	Do. " ... ..	21'00	83'99	3'99
	Total ... ..	90'00	414'99	4'61

About  $2\frac{1}{2}$  miles south of the Kensington Group are one or two leases situated at what is known as Springfield, from the first property taken up upon which a good supply of fresh water was obtained.

SPRINGFIELD, G.M.L. 4950z.—On this lease a flat lode dipping south has been worked for the the past five years by a number of shallow vertical shafts and surface working. It has not proved so far to continue of value in depth nor to extend east or west.

A vertical shaft has also been sunk to a depth of 130 feet in which a supply of 1,500 gallons per diem of fresh water was struck.

*Table showing the Yield of the Springfield Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1900 ...	Springfield, G.M.L. 4950z ... ..	39'00	25'11	'64
1902 ...	Do. " ... ..	209'00	183'14	'87
1903 ...	Do. " ... ..	115'00	88'79	'77
1904 ...	Do. " ... ..	279'00	176'77	'63
1905 ...	Do. " ... ..	145'00	110'00	'76
	Total ... ..	787'00	583'81	'74

A little north of this some old shafts on the flat indicate what was the BLOW FLY, G.M.L. 4964z, but this was only worked a short time and was never surveyed. From this lease 50'00 tons of stone were crushed, which yielded 32'29 ounces of gold.

South of Springfield is a lease called the EMU, G.M.L. 5164z, upon which a small reef which dips west is being worked, but little has been done on it as yet.

This lease was originally called the MYRTLE, G.M.L. 5082z, but the workings then consisted of some shallow shafts on a quartz reef on the hill to the westward.

Table showing the Yield of the Emu Reef.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1903 ...	Myrtle, G.M.L. 5082z ...	56'00	57'94	1'03
1903 ...	Emu, G.M.L. 5144z ...	35 00	118'70	3'39
1904 ...	Do. 5164z ...	118'00	277'29	2'35
1905 ...	Do. „ ...	177'00	417'95	2'36
	Total ...	386'00	871'88	2'26

The KURRAJONG, G.M.L. 3482z, FULCRUM, G.M.L. 5202z, and HOPEFUL, G.M.L. 5206z, lie about one and a half miles east of Mt. Misery. The first mentioned was only worked for a short time in the early days of the goldfield upon a small diorite outcrop, whilst the latter two were two small recent holdings upon patchy barren looking veins in the granite, near which some specks of gold had been discovered.

Table showing the Yield of sundry Leases.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1886 ...	Kurrajong, G.M.L. 3482z ...	5'00	9'23	1'86
1898 ...	Federal, G.M.L. 4885z ...	44'00	51'41	1'16
1905 ...	Fulcrum, G.M.L. 5202z ...	12'00	11'02	'92
	Total ...	56'00	62'43	1'11
1904 ...	Hopeful, G.M.L. 5206z ...	12'00	22 51	1'87
1904 ...	Do. „ ...	6'00	5'37	'89
	Total ...	18'00	27'88	1'54

## SUNDRY CLAIMS.

Under this head an item appears annually in the returns, with the exception of 1903, as follow:—

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
1897 ...	18'00	9'02	'50
1898 ...	118'75	140'87	1'19
1899 ...	231'25	235'04	1'01
1900 ...	179'00	155'42	'87
1901 ...	63'00	65'20	1'03
1902 ...	625'00	842'04	1'34
1904 ...	358'00	385'56	1'08
1905 ...	927'00	597'61	'64
Total ...	1,910'00	1,721'46	'90

### Section III.—Conclusion.

In order to make the occurrence of the typical Menzies lode as clear as possible (the segregation, not the fissure veins, are here referred to) a brief *résumé* of their occurrence will be given.

It will have been noted from the foregoing description of the various mines in which segregation veins were worked that the formations downwards may be divided into three zones:—1st, the upper, which extends down to the water level, in which oxidation has taken place; this zone is of variable extent even in reefs situated in close proximity, and is not entirely governed by surface configuration. 2nd, the belt of water-bearing rock or zone of saturation, the limit of which in depth is governed by the permeable nature of the formation, and may, as in the case of the Shenton Reef, be entirely absent owing to local conditions, such as an impervious laterite covering which has prevented the down flow of meteoric waters, whilst a few chains west, in sinking the main shaft, a considerable supply of water was cut which has now risen through the connecting workings and flooded the workings which were previously dry; and 3rd, below the zone of saturation, when the country rock is massive and dry, being practically impervious to the overlying water.

In the oxidised zone the rocks are usually soft near the surface, being highly weathered, consisting of yellow argillaceous and magnesian nature, passing imperceptibly into more or less weathered serpentine and chloritic schists. In this zone numerous lines of auriferous lodes are met with; they are of the composite order, consisting of a series of lenticular quartz veins or pipes which follow the rock foliation.

These veins may lie in a single line, one lens forming at or near the terminal point of the other, or, as is more commonly the case, overlapping one another, each following vein lying upon a parallel line of foliation. The lode body may be composed of a series of these parallel veins so arranged that the entire mass assumes a more or less lenticular form, i.e., increasing in thickness towards the centre and diminishing towards the ends along the line of strike. Near the surface an enclosing zone of enriched decomposed rock is not infrequently met with which is termed "formation."

Below the water level the lode changes considerably in character, the ore body becoming a sulphide lode, and consists of definite shoots and blanks; the shoots appear as a general rule to cut out upon coming in contact with the solid country, or to penetrate it for only a short distance.

Below the terminal point of these shoots considerable prospecting has been done, but so far no vein encountered has proved of sufficient value to be worth working.

Owing to the fact that the surface of the auriferous belt is for the most part covered by superficial deposits, the reefs do not as a rule outcrop, but to judge from the mode of occurrence of those already discovered, it is probable that numerous others exist, and when it is noted that a very large area in the very heart of the belt has been scarcely prospected it is quite possible that even large and rich lodes may yet be discovered.

Since the erection of the State Battery the working miners have been enabled to profitably work many of the small but rich veins of stone which the companies had abandoned, and the return from this source alone is responsible for a very considerable proportion of the annual gold production of the district; in fact, without it, since the closing down of so many large mines, the district would have retrograded considerably.

*Table showing the Return of the Ore treated at the Menzies State Battery.*

Year.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	oz.	oz.
1904 ... ..	5,067	7,508	1.48
1905 .. ...	4,188	5,502	1.33
Total ... ..	9,202	13,010	1.41

The opening up of small veins in old workings has led to further prospecting, which has in many instances been amply rewarded by the discovery of other lines. This leads to the conclusion that in the main Menzies belt beneath the alluvium a large series of parallel lines of veins very probably exist, and should this prove to be the case, although the larger lodes may be worked out, this district may reasonably look forward to a very considerable and prosperous future.

## Appendix I.

*Synoptical Table showing the Yield of the Leases at M  
to the end of 1905.*

NOTES.—(1.) Leases having the same name but are situated in different lo  
(2.) Leases with the same name covering a portion of the same gro

Name of Lease or Company.	Number of Lease.	Ore crushed.	Gold therefrom
		tons.	ozs.
Ada Ella ... ..	5185z	10'00	5'5
Adelaide (1) ... ..	3378z	13'50	17'1
Do. (1) ... ..	5128z	109'50	52'0
Africander (2) ... ..	3034z	189'00	250'4
Do. (2) ... ..	4984z	47'00	56'3
Do. (2) ... ..	5253z	34'50	38'0
Alexandra ... ..	4918z	103'00	171'8
Ancient Briton Extended	4007z	26'00	20'7
Anti-Daglish ... ..	5225z	10'00	17'7
Athelstane ... ..	4873z	458'00	204'5
Baden Powell (2) ... ..	5089z	17'00	18'2
Do. (2) ... ..	5241z	146'00	212'6
Ballarat Menzies ... ..	5113z	64'75	18'0
Barunga Brave ... ..	4691z	23'00	19'7
Battler's Rest ... ..	5143z	21'00	18'0
Bellinger ... ..	5114z	31'00	9'0
Blaas Reward ... ..	5026z	23'00	17'6
Black Horse ... ..	5106z	216'00	250'3
Black Jack ... ..	4879z	961'00	1,096'5
Black and White ... ..	4978z	82'00	35'5
Blow Fly ... ..	4954z	50'00	32'2
Brilliant (2) ... ..	4911z	13'00	8'4
Do. (2) ... ..	5184z	26'00	5'6
Bristol ... ..	5116z	26'00	7'7
Britannia ... ..	4850z	8'00	2'7
Broken Seal ... ..	5022z	35'00	25'6
Brown Hill ... ..	4949z	31'00	14'9
Busy Bee ... ..	5105z	207'00	80'7
Butterfly ... ..	4992z	97'50	167'2
Central Menzies ... ..	2834z	19'00	18'1
Christmas Gift ... ..	5016z	93'00	83'8
Columbia ... ..	5104z	18'00	9'8
Coronation ... ..	5041z	10'00	8'3
Coronation Gift ... ..	5064z	29'00	22'2
Cosmopolitan ... ..	4961z	52'00	23'7
Craig-y-Nos (2) ... ..	4940z	527'25	349'9
Do. (2) ... ..	5220z	220'00	88'1
Crown Cross (2) ... ..	4860z	234'00	181'6

APPENDIX I.—*Synoptical Table showing the Yield of the Leases at Menzies up to the end of 1905—continued.*

Same of Lease or Company.	Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
Crown Cross (2) ... ..	4912z )	594·50	1,485·03	2·49
Do. (2) ... ..	4967z ;			
Do. South Extended	4979z	101·00	498·01	4·53
Crusoe Gold Claims, Ltd. {	2823z, 3009z, } 5017z, & 5018z }	30,254·00	29,895·11	0·99
Daisy Bell ... ..	4061z	72·00	69·34	·96
Danac ... ..	5060z	10·00	3·89	·39
Double Event ... ..	5135z	74·00	61·20	·83
Dublin Castle (2) ... ..	4952z	274·00	503·18	1·83
Do. (2) ... ..	5215z	141·00	230·38	1·63
Easter Gift ... ..	5095z	23·00	5·66	·24
Emu (2) ... ..	5144z	35·00	118·70	3·39
Do. (2) ... ..	5164z	295·00	695·24	2·35
Etrenna and Aurelia ... ..	4965z & 4966z	224·25	221·24	·98
European ... ..	5210z	8·00	5·25	·65
Federal ... ..	4885z	44·00	51·41	1·17
Federation ... ..	4959z	30·00	13·19	·43
Florence ... ..	2821z	6,664·00	6,354·88	·95
Flying Fish Leases ... ..	4982z & 4991z	209·50	730·66	3·48
Flying Fish ... ..	5089z	699·00	1,261·32	1·80
Four o'clock (2) ... ..	5012z	55·00	31·31	·57
Do. (2) ... ..	5072z	73·00	69·94	·96
Freeman ... ..	5039z	30·00	20·75	·69
Fulcrum ... ..	5202z	12·00	11·02	·92
Gem Extended (2) ... ..	4849z	123·50	55·17	·45
Do. (2) ... ..	4957z	15·00	6·33	·42
Do. (2) ... ..	5015z	15·00	6·92	·46
Gift ... ..	4916z	10·00	5·37	·54
Golden Age (2) ... ..	5005z	76·00	41·09	·54
Do. (2) ... ..	5092z	47·00	54·85	1·17
Golden Butterfly ... ..	4997z	120·00	36·37	·30
Golden Crown ... ..	4973z	16·00	35·42	8·21
Golden Horsehoe ... ..	4990z	20·00	7·31	·36
Golden Shoe ... ..	4811z	44·00	51·31	1·17
Golden Star ... ..	4907z	19·00	14·13	·74
Goldenough ... ..	4855z	4447·95	6220·66	1·39
Great Hope ... ..	5090z	12·50	21·85	1·74
Great Klondyke ... ..	4853z	16·80	36·94	2·20
Guiding Star ... ..	4951z	271·35	268·26	·99
Hayles and Taverstock ... ..	5000z	84·00	107·15	1·27
Heart's Content ... ..	4947z	44·00	82·37	1·87
Home Signal ... ..	4993z	5·00	4·94	·98



**APPENDIX I.—Synoptical Table showing the Yield of the L  
Menziez up to the end of 1905—continued.**

Name of Lease or Company.	Number of Lease.	Ore crushed.	Gold therefrom.
		tons.	oss.
Homeward Bound ... ..	5173z	33'00	4'82
Hornet's Nest ... ..	4998z	5'00	1'68
Hopeful ... ..	5206z	18'00	27'88
Horseshoe ... ..	5045z	43'00	13'74
Indus ... ..	4291z	16'00	2'76
Industria ... ..	4899z	44'00	14'94
Ivy ... ..	4942z	15'00	1'58
Jingellie ... ..	4878z	42'00	28'78
Just-in-time (2) ... ..	4886z	24'00	12'04
Do. (2) ... ..	5141z	25'00	4'08
Kensington ... ..	3277z	145'00	110'38
Kensington Easter Gift ... ..	5103z	17'00	23'42
Kensington Sunday Gift ... ..	4819z	26'00	27'81
Kensington Vindicator ... ..	3615z	33'00	47'70
Klondyke (2) ... ..	5131z	16'80	36'94
Do. (2) ... ..	5156z	16'00	6'33
Do. (2) ... ..	5226z	52'00	11'72
Kurrajong ... ..	3482z	5'00	9'25
Lady Fanny ... ..	5179z	16'00	10'06
Lady Harriet ... ..	2822z	759'00	645'44
Lady Harriet Leases ... ..	4972z & 5002	2,177'00	2,023'38
Lady Main ... ..	3963z	95'00	112'64
Lady Min ... ..	4917z	15'00	56'22
Lady Sarah ... ..	5009z	138'00	127'91
Lady Shenton ... ..	2820z & 3006z	96,280'00	132,101'31
Lady Sherry ... ..	2838z	904'25	744'61
Lincoln (1) ... ..	5184z	31'00	71'71
Do. (1) ... ..	5181z	61'00	106'44
Lion (2) ... ..	5069z	48'00	115'91
Do. (2) ... ..	5244z	43'00	56'77
Little Peter ... ..	5201z	10'00	3'4
Little Tom ... ..	5083z	25'00	40'4
Little Vic ... ..	5225z	7'50	11'9
Little Wonder (2) ... ..	5139z	14'00	15'9
Do. (2) ... ..	5163z	94'00	329'9
Do. (2) ... ..	5189z	276'00	581'0
London and Coolgardie Ex- plorers, Ltd. (2)	3116z & 3118z	340'00	394'2
London and Coolgardie Ex- plorers, Ltd. (2)	5013z	43'00	60'7
Lone Hand ... ..	5230z	59'00	50'4
Lord Nelson ... ..	5021z	12'00	4'5
Lord Roberts (2) ... ..	5007z	69'00	38'0
Do. (2) ... ..	5168z	26'00	7'0

APPENDIX I.—*Synoptical Table showing the Yield of the Leases at Menzies up to the end of 1905—continued.*

Name of Lease or Company.	Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
Lucky Hit ... ..	5137z	40'00	15'24	'38
Lucky Prop ... ..	5127z	72'00	17'96	'24
Lucky Strike... ..	5194z	86'00	5'10	'14
Lucky Venture ... ..	5151z	45'00	9'49	'21
Maori (2) ... ..	4983z	64'00	80'72	1'26
Do. (2) ... ..	5196z	12'00	2'68	'22
Maori Gold Mine, Ltd. ....	3059z	571'00	654'06	1'11
Maori Chief (2) ... ..	4914z	308'00	218'41	'32
Do. (2) ... ..	4987z	543'00	474'68	'87
Mannora ... ..	4895z	2,035'30	2,135'15	1'04
McClay's Welcome ... ..	3744z	82'00	48'77	'59
Menzies, Limited ... ..	{ 2826z, 2828z, 2829z, 3050z, 3061z, 3055z, and 3056z }	308'00	457'23	1'49
Menzies Alpha Leases, Ltd. ....	3011z and 3031z	11,037'00	15,587'74	1'40
Menzies Consolidated Gold Mines, Ltd. ....	4931z, 4934z/6z	99,371'00	65,875'05	'66
Menzies Fortuna ... ..	5136z	137'00	139'74	1'09
Menzies Gift... ..	3036z	50'00	12'74	'26
Menzies Gold Estates, Ltd. {	{ 3042z, 3046z, and 3054z }	431'00	149'90	'35
Menzies Gold Reefs Pro- prietary {	{ 2824z/5z and 2842z }	6,063'00	11,293'59	1'86
Menzies Golden Age ... ..	2830z	292'50	1,059'00	3'62
Menzies Horseshoe ... ..	5145z	62'00	19'02	'30
Menzies Kensington ... ..	3277z	928'00	783'03	'84
Menzies Kensington East ...	4750z	10'00	5'20	'52
Menzies Lady Mary ... ..	3121z	14'00	1'22	'08
Menzies Lady Sherry ... ..	2835z	2,206'00	2,341'48	1'06
Menzies Luxemburg ... ..	5043z	6'00	5'02	'83
Menzies Main Reef (1) ... ..	4897z	39'00	15'98	'42
Do. (1) ... ..	5149z	37'00	10'00	'27
Menzies Mining and Explora- tion Corporation, Ltd. ....	{ 3100z, 2832z, 2843z/4z, etc. }	14,243'45	20,551'65	1'44
Menzies Pioneers ... ..	2822z	613'00	717'83	1'17
Menzies Proprietary (2) ... ..	4953z	129'25	162'69	1'25
Do. (2) ... ..	5140z	201'00	145'72	'72
Do. (2) ... ..	5236z	128'00	270'15	2'11
Menzies Star... ..	5118z	114'00	62'09	'54
Menzies United ... ..	3345z	139'00	96'09	'69
Menzies United, Ltd. ....	3151z	121'85	115'14	'94
Meriyulah ... ..	4960z	305'00	343'95	1'12
Moonlight ... ..	5183z	35'00	25'71	'73
Myrtle ... ..	5062z	56'00	57'94	1'03
Never Despair ... ..	5225z	81'00	42'10	'50
Nil Desperandum ... ..	4941z	87'00	195'77	2'25
Nugget ... ..	5209z	87'00	144'92	1'66

APPENDIX I.—*Synoptical Table showing the Yield of the  
Menzies up to the end of 1905—continued.*

Name of Lease or Company.	Number of Lease.	Ore crushed.	Gold therefrom
		tons.	ozs.
Oceanic (2) ... ..	4920z	101'00	62'1
Do. (2) ... ..	4969z	50'00	26'5
Olive Branch ... ..	5112z	40'00	8'2
Opal ... ..	5100z	30'00	4'7
Ophir ... ..	5186z	17'00	5'9
Ourine ... ..	4977z	30'00	22'8
Perseverance ... ..	5102z	98'00	29'5
Pictou ... ..	4985z	370'50	99'0
Pictou Valley ... ..	4890z	20'00	35'8
Prince Albert ... ..	4926z	21'00	11'3
Queenslander ... ..	5126z	36'00	20'3
Queensland Menzies G.M. Co. ... ..	...	44,851'00	73,808'8
Rescue ... ..	5065z	48'00	79'0
Resurgam (2) ... ..	5076z	21'00	29'0
Do. (2) ... ..	5117z	15'00	9'0
Resurrection ... ..	4859z	46'50	23'0
Rising Sun ... ..	5040z	10'00	10'0
Sailor ... ..	5109z	...	...
Secret ... ..	5232z	56'00	150'0
Sefton ... ..	5080z	8'10	12'0
Sentinal ... ..	5204z	55'00	35'0
Sophia ... ..	5233z	113'00	79'0
Springfield ... ..	4950z	787'00	583'0
St. Albans (2) ... ..	4883z	403'75	687'0
Do. (2) ... ..	5081z	73'00	109'0
Success ... ..	4980z	120'00	114'0
Sunday Gift ... ..	5010z	353'00	599'0
Surprise ... ..	5002z	123'00	116'0
Three Battlers ... ..	4871z	57'00	40'0
True Blue (1) ... ..	3322	100'00	24'0
Do. (1) ... ..	5130	97'00	186'0
True Blue South ... ..	4923	51'00	54'0
Two Walters ... ..	5207z	80'00	30'0
Union Jack ... ..	4889z	593'00	679'0
Victoria Cross ... ..	5131z	32'00	7'0
Victory ... ..	5066z	239'00	53'0
Victory North ... ..	5068z	172'50	27'0

APPENDIX I.—*Synoptical Table showing the Yield of the Leases at Menzies up to the end of 1905—continued*

Name of Lease or Company.	Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	oss.	oss.
Victory South ... ..	5094z	287·00	311·81	1·08
Viking ... ..	5088z	90·00	414·99	4·61
Vindicator South ... ..	4924z	29·00	32·83	1·12
Walleroo Menzies G.M. Co.	3235z & 3398z	12·00	2·42	·20
Warrior Menzies G.M. Co.	3048z	1,153·00	729·06	·63
Warrior ... ..	3048z	650·00	418·49	·64
Welcome ... ..	5101z	90·00	24·53	·27
West Sea ... ..	4908z	12·00	7·43	·62
W.A. Development Syndicate	3206z	177·50	113·17	·63
Westralia Menzies ... ..	5034z	20·00	32·56	1·14
Witch Hazel ... ..	5154z	21·00	8·82	·42
Sundry Claims ... ..	...	1,910·00	1,721·46	·90

## Appendix II.

*List of Specimens in the Geological Survey Museum from the Menzies District.*

Registered Number of Specimen.	Registered Number of Micro-slide.	Name of Specimen.	Locality of Specimen.	Remarks.
750	...	Serpentine schist	Alpha, G.M.L. 3011z	
751	24	Mica schist	Warrior, G.M.L. 3048z	
752	...	Serpentine schist	Golden Age, G.M.L. 2830z	
753	...	Ironstone	G.M.L. 3478z	
754	23	Hornblend schist	Alpha, G.M.L. 3011z	
755	...	Mica schist	Warrior, G.M.L. 3048z	
756	...	Lode stuff	Shenton North, G.M.L. 2826z	
757	...	Mica schist	Occidental, G.M.L. 3340z	do.
758	...	Weathered diorite	do.	do.
759	...	Quartzite	Marie, G.M.L. 4576z	do.
760	...	Ferruginous quartzite	do.	do.
761	...	Weathered granite	Water right, 234	do.
762	...	Weathered hornblend schist	do. 189	do.
763	...	Decomposed schist	Lady Sherry, G.M.L. 2835z	
764	...	Gneissic granite	Lady Mary, G.M.L. 3121z	
765	...	Bedded kaolin	Water right, 262	
766	...	Siderite, on gneissic granite	Lady Mary, G.M.L. 3121z	do.
767	...	Hornblend rock (gneissic)	do.	do.
768	...	Hornblend rock	Hill upon east side of town	do.
769	...	Schistose diorite	do.	do.
770	...	Ironstone	Mt. Owen	
771	...	Ferruginous quartzite	Liberator East, G.M.L. 4084z	
772	...		Shenton Extended, G.M.L. 3124z	
773	...			
774	...			
775	...			
776	...			
802	...			

811	Diorite	...	...	...	Union Jack, G.M.L. 3042z
812	Mica schist	...	...	...	Zetia, G.M.L. 4225z
813	Hornblond schist	...	...	...	Daisy Bell, G.M.L. 4011z
814	Mica schist	...	...	...	Robbie, G.M.L. 4047z
1036	Weathered schist	...	...	...	Lady Shenton, G.M.L. 2820z
1037	Sample of lode at surface	...	...	...	do.
1038	Do.	...	...	...	do.
1039	Lode stuff, showing paint gold, 60ft. level	...	...	...	do.
1040	Diorite, carrying galena and gold, 230ft. level	...	...	...	do.
1041	Sulphide stone, 210ft. level	...	...	...	do.
1042	Mineralised stone, assaying 14'70ozs., 250ft. level	...	...	...	do.
1043	Casing of reef	...	...	...	do.
1044	Wall of reef	...	...	...	do.
1045	Auriferous diorite (crushing stone)	...	...	...	do.
1046	Auriferous quartz, 160ft. level	...	...	...	Florence, G.M.L. 2821z
1047	Schistose felstone	...	...	...	Jowett's Well
1048	Serpentine schist	...	...	...	Princess May, G.M.L. 3113z
1049	Gneissic felstone	...	...	...	Darwin, G.M.L. 3024z
1050	Do.	...	...	...	do.
1051	Do.	...	...	...	do.
1052	Gneissic felstone (auriferous)	...	...	...	Darwin, G.M.L. 3024z
1053	Quartz vein in serpentine	...	...	...	Princess May, G.M.L. 3118z
1054	Fibrous serpentine	...	...	...	Hidden Treasure, G.M.L. 4750z
1055	Semi-fibrous serpentine	...	...	...	do.
1056	Sericite schist	...	...	...	do.
1057	Do.	...	...	...	do.
1058	Do.	...	...	...	do.
1059	Gneissic felstone (auriferous)	...	...	...	Hill N.W. of Emu, G.M.L. 5164z
1060	Quartz vein in serpentine	...	...	...	Hill south of Springfield, G.M.L. 4950z
1061	Fibrous serpentine	...	...	...	Hill N.W. of Emu, G.M.L. 5164z
1062	Semi-fibrous serpentine	...	...	...	Half-mile east of Emu, G.M.L. 5164z
1063	Sericite schist	...	...	...	South of the Water Reserve fence
1064	Do.	...	...	...	Hill half-mile N.E. of Merry's Well
1065	Do.	...	...	...	do.
1066	Weathered schist	...	...	...	do.
1067	Gneiss	...	...	...	do.
1068	Felsite dyke	...	...	...	do.
1069	Banded quartzite	...	...	...	do.
1070	Silicified diorite	...	...	...	do.
1071	Weathered sericite schist	...	...	...	do.
1072	Iron ore (limonite)	...	...	...	do.
1073	...	...	...	...	Road half-way between Woolgar and Merry's Well
1074	...	...	...	...	...
1075	...	...	...	...	...
1076	...	...	...	...	...
1077	...	...	...	...	...

APPENDIX II.—*List of Specimens in the Geological Survey Museum from the Menzies District—continued.*

Registered Number of Specimen.	Registered Number of Micro-slide.	Name of Specimen.	Locality of Specimen.	Remarks.
1176	...	Pisolithic iron ore with secondary silica	Half-mile west of Merry's Well	
1179	380	Quartz schist ...	Hill N.W. of the Emu, G.M.L. 5164z	
1180	26	Hornblend schist	Hill north of Merry's Well	
1182	...	Quartz ...	Half-mile east of Emu, G.M.L. 5164z	
1184	...	Sericite schist	Hill N.W. of Emu, G.M.L. 5164z	
1185	...	Weathered felsite	Barunga Brave, G.M.L. 4691z	
1186	...	Granitic gneiss	Explosive Reserve	
1187	...	Weathered schist	Half-mile east of the Emu, G.M.L. 5164z	
1188	...	Sericite schist	Quarter-mile S.W. of Emu, G.M.L. 5164z	
1189	...	Quartzite	Barunga Brave, G.M.L. 4691z	
1190	...	Sericite schist	Ulster, G.M.L. 4757z	
1191	...	Quartz porphyry	South of the Water Reserve	
1192	...	Hornblend diorite	S.E. corner of Water Reserve fence	
1193	...	Weathered schist	Ridge half-mile N.E. of Merry's Well	
1194	...	Felsite dyke	Ridge three-quarters-mile N.W. of Merry's Well	
1195	...	Mica schist	Ridge half-mile N.E. of Merry's Well	
1196	...	Serpentine schist	Hill east of Emu, G.M.L. 5164z	
1197	...	Pyriteous lode stuff	Czar, G.M.L. 4678z	
1198	...	Amphibolite	do.	
1199	...	Mica felsite	N.W. of Merry's Well	
1200	...	Decomposed granite	Road between Woolgar and Merry's Well	
1201	...	Serpentine schist	Half-mile east of Emu, G.M.L. 5164z	
1202	...	Quartzite	Hill half-mile N.E. of Merry's Well	
1203	...	Ironstone	Half-mile east of Emu, G.M.L. 5164z	
1204	Do	...	Half-mile S.W. of Emu, G.M.L. 5164z	

6315	Limestone	...	...	...	...	...	...	...	Near Emu, G.M.L. 5164z
6316	Do.	...	...	...	...	...	...	...	Corner of G.M.Ls. 4781z and 4359z
6317	Limonite	...	...	...	...	...	...	...	S.E. corner of Water Reserve
6318	Granite	...	...	...	...	...	...	...	G.M.L. 3112z
6319	Orthoclase	...	...	...	...	...	...	...	do.
6320	Quartzite	...	...	...	...	...	...	...	Springfield Road, S.E. of G.M.L. 4359z
6321	Sericite schist	...	...	...	...	...	...	...	do.
6322	Dolomite	...	...	...	...	...	...	...	Crusoe, G.M.L. 2823z
6323	Asbestos	...	...	...	...	...	...	...	do.
6324	Schist from fault wall	...	...	...	...	...	...	...	Queensland Menzies, G.M.L. 3836z
6325	Serpentine schist	...	...	...	...	...	...	...	Crusoe, G.M.L. 2823z
6326	Hornblend schist (weathered)	...	...	...	...	...	...	...	do.
6327	Do. (micaceous)	...	...	...	...	...	...	...	do.
6328	Mica schist	...	...	...	...	...	...	...	Shaft half-mile west of Goodenough, G.M.L. 4855z
6329	Amphibolite	...	...	...	...	...	...	...	do.
6330	Do.	...	...	...	...	...	...	...	Shaft north of Goodenough, G.M.L. 4855z
6331	Aphanitic diorite	...	...	...	...	...	...	...	Menzies Alpha Leases, G.M.L. 3031z
6332	Mica schist	...	...	...	...	...	...	...	Menzies Gold Estate, G.M.L. 3054z
6333	Do.	...	...	...	...	...	...	...	Golden Age, G.M.L. 2830z
6334	Crushed porphyritic granite	...	...	...	...	...	...	...	do.
6335	Quartz porphyry	...	...	...	...	...	...	...	do.
6336	Porphyritic granite	...	...	...	...	...	...	...	McClay's Welcome, G.M.L. 3744z
6337	Weathered porphyritic dyke	...	...	...	...	...	...	...	Lady Shenton, G.M.L. 5006z
6338	Do.	...	...	...	...	...	...	...	Goodenough, G.M.L. 4855z
6339	Granite	...	...	...	...	...	...	...	Golden Shoe, G.M.L. 4861z
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APPENDIX II.—*List of Specimens in the Geological Survey Museum from the Menzies District—continued.*

Registered Number of Specimen.	Registered Number of Micro-slide.	Name of Specimen.	Locality of Specimen.	Remarks.
6340	...	Sericite schist	Goodenough, G.M.L. 4855z	
6341	...	Weathered porphyritic dyke	Ray's Water Shaft	
6342	...	Mica schist	Florence, G.M.L. 2821z	
6343	...	Weathered porphyry	Princess, G.M.L. 2829z	
6344	...	Gneissic rock	N.W. corner of G.M.L. 4861z	
6364	...	Mica schist	Goodenough, G.M.L. 4855z	
6365	...	Sericite schist	G.M.L. 4789z and ridge to southward	
6366	...	Crushed granite	Federal, G.M.L. 4885z	
6367	...	Felsite	Quarries in Water Reserve	
6368	619	Do.	do.	
6369	620	Do.	do.	
6370	...	Do.	do.	
6371	...	Porphyritic dyke	Warrior, G.M.L. 3048z	

NOTE.—Specimens numbered from 750 to 1319 were collected by Mr. Campbell when acting as Topographical Surveyor.

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Menzies L.R.	...	...	...	...	...	...	...	...	...
Menzies Luxemberg Lease	...	...	...	...	...	...	...	...	...
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Shirkin Lease ... ..	...	...	...	...	...	...
Sophia Lease ... ..	...	...	...	...	...	...
Springfield Lease ...	...	...	...	...	...	...
State Battery ... ..	...	...	...	...	...	...
Stirling Lease ... ..	...	...	...	...	...	...
Storm King Lease ...	...	...	...	...	...	...
Stuart Lease ... ..	...	...	...	...	...	...
Success Lease ... ..	...	...	...	...	...	...
Sunday Gift Lease ...	...	...	...	...	...	...
Sundry Claims ... ..	...	...	...	...	...	...
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Taipo Lease ... ..	...	...	...	...	...	...
Taipo South Lease ...	...	...	...	...	...	...
Te Pakeha Lease ... ..	...	...	...	...	...	...
Three Battlers Lease ...	...	...	...	...	...	...
True Blue Lease ... ..	...	...	...	...	...	...
True Blue South Lease ...	...	...	...	...	...	...
Two Walters Lease ...	...	...	...	...	...	...
Ulster Lease ... ..	...	...	...	...	...	...
Union Jack Lease ... ..	...	...	...	...	...	...
Victoria Cross Lease ...	...	...	...	...	...	...
Victory Lease ... ..	...	...	...	...	...	...
Victory North Lease ...	...	...	...	...	...	...
Victory South Lease ...	...	...	...	...	...	...
Viking Lease ... ..	...	...	...	...	...	...
Vindicator South Lease ...	...	...	...	...	...	...
Wallaroo Menzies G.M. Co., N.L.	...	...	...	...	...	...
Warrior Lease ... ..	...	...	...	...	...	54, 58,
Warrior Menzies G.M. Co., N.L.	...	...	...	...	...	...
Water Supply ... ..	...	...	...	...	...	...
Wedderburn Lease ... ..	...	...	...	...	...	...
Welcome Lease ... ..	...	...	...	...	...	...
W.A. Development Syndicate	...	...	...	...	...	...
W.A. Proprietary Co. ...	...	...	...	...	...	...
W.A. Venture Corporation	...	...	...	...	...	...
Westralia Menzies Lease ...	...	...	...	...	...	...
West Sea Lease ... ..	...	...	...	...	...	70
Wilson's Lease ... ..	...	...	...	...	...	...
Witch Hazel Lease ... ..	...	...	...	...	...	...
Woolgar ... ..	...	...	...	...	...	20, 62
Yunndaga ... ..	...	...	...	...	...	...
Zeta Lease ... ..	...	...	...	...	...	...

BULLETIN N° 22.







### DIVISION III

#### THIRD REPORT, 1905

#### PART I.—DESCRIPTIVE GEOLOGY

A reconnaissance of the Pilbara Goldfield, commenced and completed at the close of the field season of 1905. On the portions of the district not previously visited were the Yule River, and the Pilbara Goldfield entered by the Yule River at Womerina Pool.

Womerina Pool is the site of a small alluvial gold mine. The pool itself lies at the foot of a long ridge which forms a gigantic horseshoe of several miles in length, the northern arm of which returns to the Yule River near Womerina Pool, some miles to the south of Womerina.

At this place the banded quartz which constitutes the main ore is of considerable thickness and underlies at a very shallow depth to the south. At the scene of the alluvial rush near Womerina the laminated quartz has been subjected to a constant disturbance of disruption (Fig. 51). A well marked fault locally 156 degrees is seen traversing the banded quartz high cliffs in the vicinity.

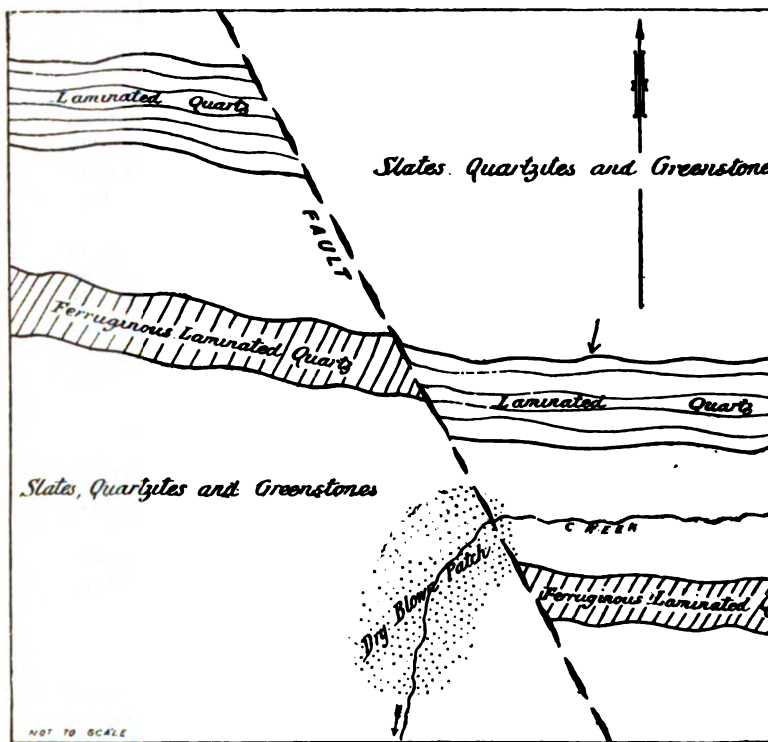
The creek, falling into the Yule River and draining the area, has been the one which has carried the bulk of the gold. Judging by the continuation of the workings, the gold seems to have been obtained in the vicinity of the fault which crosses the valley at angles. The laminated quartz veins are associated with slates, and cleaved greenstones of the type common in the centres.

Between the arms of the horseshoe, the country which forms part of that occupying such extensive area. Where the range is crossed by the track to Linfield, the slates and other associated rocks give rise to a range, which sends out veins and dykes into them.

Regarding the identity of the geological structure of this area, the portions of the district in which tin mining has been carried out, there seem good grounds for advising that attention be paid to prospecting the margin of the intrusive in the neighbourhood in the hope of finding tin also.

From the Womerina Range to Wodgina the track passes over nothing but granite of the prevailing type; this, however, gives place in the vicinity of the latter locality to a series of highly inclined metamorphosed sedimentary and igneous rocks. These have been very much folded and faulted, and they occupy a rugged range which rises to considerable altitudes above the general level of the surrounding granite plains. The metamorphic beds are pierced by granite and pegmatite veins, which emanate from the

FIG. 51.



SKETCH PLAN AT WOMERINA POOL. YULE RIVER.

main mass; these rocks are fully described on a later page (p. 25) under the heading of the Wodgina Tinfield.

In certain parts of the Wodgina field, at the Stannum group of leases, the rocks are traversed by an older series of acidic dykes which have been very much cleaved and sheared, and are intersected by the newer pegmatitic granite veins of the Wodgina type.

The intrusive granite of Wodgina occupies the whole of the watershed of the Yule River to a point at the foot of the



ge, below Cangan Pool, on the western branch extends without interruption as far to the eastward as Western Shaw. In the vicinity of Tambourah Creek, the older crystalline schists, which form the auriferous quartz reefs of these centres, again make and occupy a fairly extensive belt. Everywhere the granite is found sending out tongues and schists, and in many cases large lenticular masses of schist caught up in the granite. Full details regarding this part of the field are given on a later page (p. 223) of the report which includes the descriptions of the centres.

From Western Shaw *en route* for the Cooglegong Tinfield, the belt of schists as far to the southward as the Tambourah and Western Shaw Creeks. A little to the south the schists give place to granitic gneiss, which may contain portions of the older schists which have been absorbed in the granite.

The Cooglegong occupies a wide expanse of country, covering an area of some hundreds of square miles.

Along our route lay by way of the Black Range the tributaries of the Shaw. In the vicinity of this range is covered by the basal conglomerate of the Nullagine with its associated volcanic rocks, occupies the base of the series has been mined. Full details of the geology of this centre are given on a later page of that portion of the report which describes the centres.

From Just-in-Time to Marble Bar the route traverses the base of the Marble Bar-Yandicoogina belt, which have been described in previous reports; hence no further reference is made hereto in this place.

B. Talbot, the Field Assistant, on returning to the horses and equipment, furnished the following description of the route from Marble Bar to the Turner River:—

The route followed was *via* Cooglegong, and, as you had travelled that road, no notes were made regarding the geology of the country traversed. From the Shaw Creek *via* Dead Bullock Well and Abados Station to

the Shaw River, the track skirts along the southern base of the range for about 4 miles, the country being composed of granite. The granite then gives place to schists, of general strike of nearly north and south. Judging from the granite outcropping at the edges of the schist, they appear to be intrusive into the latter. The road follows the schist for about 3 miles, when the country rock is granite, which in many places rises into hills

covered with little or no vegetation. When the track leaves the granite it crosses the northern continuation of the Tambourah and Western Shaw belt, which at this point is about 4 miles wide and consists of slates, quartzites, and fine conglomerates, traversed longitudinally by numerous laminated ferruginous quartz reefs. The general strike of the rocks is in a northerly and southerly direction. After traversing this belt the road emerges into the large granite plain, which occupies such a large area in this portion of the Pilbara Goldfield.

"Near Abados Station several greenstone dykes outcrop and strike about north-north-east. One of these dykes rises abruptly from the plain and, extending for several miles across country, forms a conspicuous feature in the landscape.

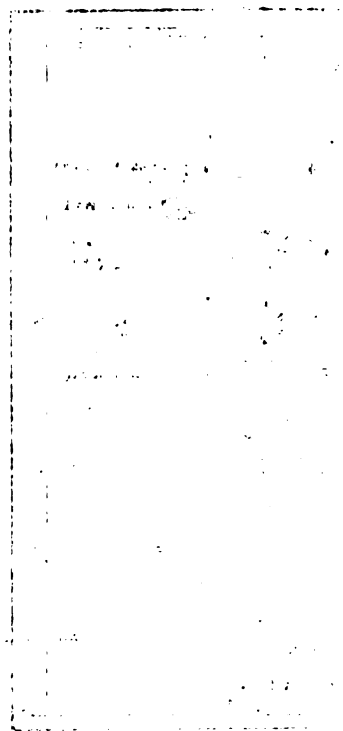
"At White Cliffs Pool, on the Turner River, and about 9 miles from Abados, an area of about 1 square mile is occupied by a dark coloured igneous rock, much weathered, and possessing a schistose structure. Its relation to the granite was not ascertained. At the pool this rock is overlain by a pure white travertine, which, on the west bank of the river, forms cliffs about 40 feet in height.

"From White Cliffs Pool to Green's Track the road runs close to the Turner River, and the rock seen on the roadside consists solely of granite.

"A description of the country from the intersection of the Turner River by Green's Track has already been published,<sup>1</sup> and therefore does not need repetition."

<sup>1</sup> Annual Progress Report of the Geological Survey for the Year 1904. Perth: Authority, 1906. pp. 147-149.







## DESCRIPTIONS OF INDIVIDUAL MINING CENTRES

### M.—Tambourah

*a Geological Sketch Map. Plate XV.)*

Tambourah is situated about 75 miles from the Bar, upon the head-waters of the creek, from which it takes its name, and which forms one of the important branches of the Haw River. The old mail-coach road from Sydney to the mine passes through both Tambourah and

Tambourah lies just to the west of the junction of the creek with the intrusive granite, which extends without any interruption as far as the old Pilbara mining camp (also on the same line), about 70 miles to the north-west. The auriferous zone has yet been proved, extends for about a couple of miles north and south, at an average distance of about a mile from the granite junction, as may be seen by an inspection of the geological sketch map.

Mineral leases were in force at Tambourah during the early years of the colony, but at the present time there are none, and the place presents a very prosaic appearance.

A shaft, 97 feet in depth, had been sunk on the Tambourah Creek, at the spot indicated on the map. In 1894 a drive had been put in 12 feet north-west, which is estimated at about 100 gallons per day of fresh water.

The vicinity of Tambourah consists of a series of low hills, which rise to no conspicuous altitudes above the level of their surroundings.

Mineral-bearing timber are not abundant, but doubtless the want of a small centre for a few years past has been within reasonable distance of Tambourah.

### HISTORY

There is no record to have been officially recorded of the early history of Tambourah. The Acting Inspector of Mines for the year 1894-5, writes of

the outskirts of another vast granite area, which stretches to the north. The character of the country differs from that of the south, the hills being low and more rounded. The



formations, too, consist mainly of hornblende-schists, diorite, and granite. The outcrops of the reefs are small, but they mostly widen out in the west. Very rich stone has been obtained from some of the workings, and the general character of the quartz is very "kindly." Some is highly mineralized with ores of iron, copper, and manganese. From Tambourah Creek it extends westwards for some 80 miles along the eastern side of the Yule River, and extends a vast area of granite country, apparently reaching back east to the Upper Shaw Country.<sup>1</sup>

The following year the same officer reports:—

With the probability of erection of batteries at the North Shaw, and at Tambourah Creek, these two very promising centres should soon add considerably in importance.<sup>2</sup>

The Warden, in his report on the Pilbara Goldfield for the year 1897, informs the Minister for Mines that:—

Tambourah Creek, situated 75 miles south-west of Marble Bar, has a population of about 40. It enjoys the convenience of a post and telegraph office, a wayside house, and two stores. One battery is erected, and a Peruvian mill is being erected. The only Company interested in this district is the World's Fair Mining Co., Ltd., who hold four leases. There are besides, nine other leases and three protection areas. The yield of gold for the year was 305 ozs. out of 142 tons.<sup>3</sup>

In his report for the year 1901, the Warden writes that:—

Mining matters at . . . Tambourah, Western Shaw, . . . were very quiet, only a few miners being employed.<sup>4</sup>

No further mention is made of the progress of Tambourah Creek in the Annual Reports of the Department of Mines since 1901, the goldfield having gradually declined until at the present date it may be said to have been practically temporarily abandoned.

Owing to difficulties connected with obtaining their ore crushed, the owners of the Kirkpatrick Mine, G.M.L. 464, erected in 1898 an arrastra on the granite rise, on the southern bank of Tambourah Creek at the spot shown on the map. It appeared, however, that the arrastra did not prove an unqualified success, though it did excellent work in reducing the ore to a fine powder, but it was too slow for the owners.

## GENERAL GEOLOGY

In its geological structure the neighbourhood of Tambourah Creek is comparatively simple, there being practically only two formations within the limits of the area mapped, viz., granite and its derivatives; and greenstone and its transmuted varieties.

### THE GRANITE.

The granite occupies the western portion of the field, and forms the margin of that large mass which extends for considerable

<sup>1</sup> Report of the Department of Mines for the year 1895. Perth: By Authority, 1896.

<sup>2</sup> Report of the Department of Mines for the year 1896. Perth: By Authority, 1897.

<sup>3</sup> Report of the Department of Mines for the year 1897. Perth: By Authority, 1898. pp. 23-24.

<sup>4</sup> Report of the Department of Mines for the year 1901. Perth: By Authority, 1902.

north, south, and west. The granite is intrusive, and passes into the greenstones, in addition to containing masses of the latter, more especially along its margin. A conspicuous mass of intrusive granite, about 8 chains in length, makes its appearance in the Tambourah Queen's Range due north for a distance of about 30 chains. It is traversed by several quartz reefs, one of which separates the granite and the enclosing greenstone.

The granite presents much uniformity, a typical example [6487] being exposed in the operations connected with the construction of the arrastra on the southern bank of Tambourah Creek. The granite, as developed in this locality, is of a light grey fine-grained grain, and consists, so far as may be judged by the unaided eye, of quartz, felspar, and small white or pale-green mica. Microscopic examination reveals nothing of especial note in regard to its structure. A granite dyke which traverses the Western Chief is composed of a rock of much finer grain [6488] than the rest.

The rock has undergone a certain amount of alteration. A hand specimen presents all the characters of a sericitic schist (granulite?). Both black and white mica are recognised by the unaided eye. Examined microscopically, it is found to consist principally of a fine-grained felspar and quartz, through which are scattered numerous grains of quartz. The micas are now represented by sericite, though a little sericitic mica can be detected. In the eastward, and in the same dyke [6490], at a distance from the granite, the rock is of a much finer grain, and has a much more platy and semi-schistose structure. Under the microscope it presents no essential differences to that observed, beyond that in the fine quartz-felspar mosaic texture, which is not at first very conspicuous, can be

#### GREENSTONES AND THEIR DERIVATIVES.

A large portion of the district is occupied by basic rocks, and the observations have at present been carried, belonging to such differences as they present being brought into view after their consolidation. All these rocks are marked by foliation, the lines of which have a general strike north and south, with a very high inclination to the eastward. In some cases the rocks are hornblende-schists, and in others greenstones; they are all dark, heavy rocks [6485], and an important characteristic of most of them is the presence of both brown and green hornblende.

One of the schistose varieties [6485] from a mass which is exposed in the granite, near the western margin of the Western Chief, when examined under the microscope, is found to consist of hornblende, some of which shows the characteristic

prismatic cleavage. The matrix in which the hornblende consists chiefly of grains of fresh coloured felspar, showing un-crossed nicols lamellar twinning; the felspar contains acid inclusions of apatite (?). There is a relatively small quantity of iron ore which is in all probability ilmenite.

What appears as a long dyke of greenstone [6486] outcrops on the eastern boundary of the Duke of Wellington and Corunna Leases; it may, however, be merely an attenuated part of unmodified greenstone, which has escaped total destruction. Under the microscope, the rock [6486] is found to consist chiefly of hornblende, which has in most cases lost all traces of original form, and is crowded with inclusions; the felspar is represented by cloudy patches which occasionally contain acid needles of hornblende and apatite (?). From its mode of occurrence it seems to indicate that the felspar has undergone a more or less complete molecular reconstruction. The small quantity of iron ore appears to be ilmenite.

The country rock [6493] of the Tambourah King Reef is somewhat fine grain and exhibits a rude foliation in hand specimen and contains a little iron pyrites. Under the microscope, the rock is found to be made up of brown and green hornblende, cloudy pellucid felspar, and fairly large quantity of iron ore, which seems to be largely ilmenite.

The rock [6489] which occurs in the Government Well is more foliated than any of the others in the district. In hand specimens the rock exhibits more recognisable crystals, but has the appearance of a somewhat unctuous chlorite schist, and under the microscope no distinguishing features.

No observations were made regarding the effects of the contact metamorphism on the greenstones in the vicinity of the granite junction.

#### THE QUARTZ REEFS.

The quartz reefs are very numerous and occur both in granite and the greenstones, though they are more numerous in the latter.

The quartz of most of the reefs, as far as can at present be seen, is of white or amber colour; as seen underground by Inspector Becher, the stone "is heavily mineralised with iron pyrites, arsenical iron pyrites and galena being also present. At water-level these ores have been mostly converted into oxides, leaving the stone sometimes in a honeycombed state with free iron in the spaces, pointing to the fact that the sulphides have carried gold in combination."

The reefs naturally vary in size within very wide limits; from what can be learnt at the present time, it appears that the smaller reefs carry the richer stone, and on the whole it may be said that Tambourah is a field of small reefs.

An inspection of the map, upon which the position of all



been laid down with such a degree of accuracy as circumstances seemed to warrant, shows that when they exhibit a rude parallelism coincident with the line of the district, viz., north and south.

One of the greatest linear persistence is that which runs through the Chief Leases, and can be followed southward for a distance of about 6000 feet, and extends farther than the limits embraced by the

reefs all vertical, or at any rate are inclined at a high angle. The longest reef, viz., the one previously mentioned, in its northern portion into a very banded form, and is in respect with those laminated quartz veins which are characteristic features in the geology of other centres in the field and the other mining fields throughout the

reefs of Tambourah have yielded up to the close of 1895, 2253·25 lbs. of gold, derived from the milling of 2253·25 tons of ore at the rate of 1·60 ozs. per ton.

It has been shown that the relation between the granite and the greenstone is that the former is intrusive into the latter, and that the veins traverse both series indiscriminately, although they are more numerous in the greenstone. It necessarily follows that the fact has a very important bearing upon the geology of the other north-west fields, which are geologically similar to the quartz reefs are likely to be as persistent in the kind can ever be, and they are not liable to be preceded by the granite as might have been the case had the reefs preceded the intrusion thereof.

#### THE ORE DEPOSITS AND MINES.

In the following description, the ore deposits and workings are arranged in geographical sequence, commencing at the northern

G.M.L. 410 (formerly G.M.L. 265).—This is an area of about a little over half a mile due north of the boundary, in all probability traversed by the extension of the reef which crosses the Duke of Wellington and extends to the south, and has been followed about a quarter of a mile up to the boundary of the geological map. No

*Showing the Yield of the Brilliant G.M.L. 410.*

	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
.	35·00	21·60	·61

work was going on at the date of my visit, hence no inspection of the lease was made. Only a few ounces of gold have been obtained from this property, the details in connection with which are given in the preceding table.

KIRKPATRICK, G.M.L. 464.—This is an old unsurveyed lease situated about 10 chains north 70 degrees east from the Briarley Lease, and lies just outside the northern boundary of the geological sketch map (Plate XV.). No work was going on at the date of my visit, and had not been for years, hence the property has been unvisited.

The following table gives the official returns from the property as deduced from official data:—

*Table showing the Yield of the Kirkpatrick, G.M.L. 464.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	88.00	208.50	2.36

CORUNNA, G.M.L. 272.—This 12-acre lease, which adjoins the Duke of Wellington on the north, is traversed by three distinct lines of reef. The westernmost reef, which is coterminous with the adjoining lease, outcrops at an average distance of about 100 feet from the western boundary, and can be readily followed along the surface for about 800 feet northwards. This reef has been opened out by an underlay shaft, stated to have been carried to a depth of about 30 feet, but is inaccessible at the present time. The reef appears to be small, and the prospects are stated not to have been very encouraging. There seems to be good ground to believe that this reef may be the northern extension of the reef cropping in the Tambourah King Lease (*q.v.*).

Two hundred and fifty feet east from the previously mentioned shaft is another, sunk to a depth, of which there is no record, one of the most persistent lines of reef occurring within the limits of the country examined. This reef, which traverses the whole length of the lease, at an average distance of about 100 feet from the eastern boundary of the property, can be followed continuously along the surface for a distance of about 3000 feet, and for a considerable distance beyond the limits of the geological map (Plate XV.). The reef, which is small, is encased in the planes of foliation of a very hard hornblende schist.

Three hundred and forty feet to the south-east of the westernmost shaft is another sunk to a depth, of which there appears to be no record, on a well-defined quartz reef, underlying east at a high angle. The reef, which is small, can be followed along the strike for about 500 feet, and extends into the adjoining lease to the south.

Another small but well-defined reef outcrops at about 220



est angle of this lease, not far from the boundary granite. This reef has been opened out by a shaft, sunk however only a few feet; it can be readily traced outcrop for a distance of about 500 feet.

ELLINGTON, G.M.L. 264.—The southern portion of the lease is traversed by Tambourah Creek, which in this lease has a width which varies from 150 to a little

more. Several lines of reef traverse the property in a general north-south direction. At the time this property was at work, these different reefs were respectively known by the names "King," the "Intermediate" and the "Chief," and from which there seem to be some sound geological reasons for representing the northern extension of the main reef as traversing the Tambourah King and the Western

King reef (The King Line) is described by Mr. E. J. King of three small parallel leaders outcropping at intervals of 20 feet, and can be traced right across the property. The reef has been opened up at intervals along its length for a distance of about 200 feet. The reef is enclosed by a massive schist and underlies at a very high angle to the surface. A shaft has been sunk upon it to a depth, of which only a few inches at the surface the reef was only a few inches thick; at a depth of 30 feet (at which depth good quartz was encountered) it had increased to 24 inches. The reef, as all the others on the field, is inaccessible. A shaft has been put down upon the same reef, at a point northwards and attained a depth of 25 feet; from this shaft it is stated that a south drive was commenced with the intention of coming up with the first mentioned shaft.

No work of any importance appears to have been done since the opening of reef.

THE WESTERN CHIEF, G.M.L. 567 (L. 536).—This lease of 12 acres is the original prospecting area granted to Mr. E. J. King and was taken up in its present shape by Mr. J. S. Forbes in 1901 under the same name.

It is situated in the adjoining property (the Western Chief) and traverses the whole length of the lease, and judging from the appearance of the surface, a considerable amount of work has recently been carried out. The ground having been worked in the year 1901, all the workings being inaccessible and there being no plans of the mine lodged with the authorities, no information as to the condition of affairs present and future is available.

Several quartz reefs traverse the whole length of the lease. A well marked band of laminated quartzite outcrops at intervals from 20 to 60 feet to the east of the main reef, and continues northwards without any break as far as the southern

bank of the Tambourah Creek. This band, which forms an important feature in the structural geology of the field, can be followed southwards through the Western Chief and the Alexander where it merges into a quartz reef; it thus has a continuous outcrop of over 6000 feet within the area embraced by the map which forms Plate XV.

The westernmost reef, which is continuous from the Western Chief Lease, enters the property at a point on the southern boundary, about 140 feet east from the peg at the south-west angle of the lease, and can be followed without any break northwards, where it passes into vacant ground at a point on the northern boundary about 340 feet east of the north-west corner. It, however, has only been opened up at one spot 140 feet distant from the northern boundary of the lease; here a pothole but a few feet deep exposes a little over 12 inches of a somewhat ferruginous quartz. The main reef, which is parallel to this one and about 100 feet to the east of it, is likewise continuous throughout the whole length of the property. The reef has been opened up by seven or eight shafts, the positions of which are shown on the map. These shafts having all fallen in, are not now accessible.

*Return showing the Yield of the P. A.*

Year.	Ore Treated.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	<sup>1</sup> 103·00	<sup>2</sup> 103·00	1·00
1898 . . . . .	<sup>1</sup> 48·00	72·00	1·50
1898 . . . . .	<sup>3</sup> 23·00	38·60	1·67
Total . . . . .	174·00	213·60	1·22

The following table gives the yield of the Western Chief reef in so far as such can be obtained from official sources:—

*Table showing the Yield of the Western Chief,  
G.M.L. 567 (l. 536).*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	183·00	225·00	1·23
1899 . . . . .	363·00	416·75	1·14
1900 . . . . .	108·00	122·15	1·13
Total . . . . .	654·00	763·90	1·16

What is known as the P. A. is now embraced within the limits of the Western Chief Lease, and, according to the issues of

<sup>1</sup> Vide *Northern Public Opinion* for 25th June 1898.

<sup>2</sup> The paper states that the 103 tons yielded "a little more than an ounce per ton."

<sup>3</sup> Vide *Northern Public Opinion* for 20th August 1898.



*Opinion*, during 1898, 174 tons of ore yielded of gold. The details are given for what they are preceding table; in all probability, however, these been included in the yield of the Western Chief

CHIEF No. 1 SOUTH, G.M.L. 568 (l. 258).—This which occupies the central position of the Tames, was originally taken up in the year 1895 by and others, under the name of the Western Chief, G.M.L. 258. On being abandoned it was retaken Forbes, under the same boundaries, and registered per and name by which it is at present known. It regretted that the name of the lease has been altered, on is apt to arise on the part of the general public, in cases in which personal acquaintance with the ng.

stern boundary of the lease and on the high ground remarkably well-defined quartz reef can be traced the whole length or breadth of the property. This opened out at one spot only, distant about 140 feet ern boundary of the ground. Here at a spot where es a dyke of what is now granitic schist, a vertical sunk to a depth of 10 feet. The northern face of es 2 feet 6 inches of quartz inclined at an angle of he east. The footwall of the reef is a micaceous (?), whilst the hanging wall is a dark micaceous ea schist contains stringers of quartz, whilst the rs along the bedding (or foliation) planes. As nd in this shaft the impression left on the mind is s merely another phase of the silification of the long a well-defined line of weakness. The quartz ertainly does not present a promising appearance. echer's notes indicate clearly that the quartz of this

operations have apparently been centred upon the 60 feet to the eastward. This reef seems to have by four shafts, the positions of which are shown which forms Plate XV.

gives several particulars with regard to the work- se; it is unfortunately not quite clear which of the pon the map are those to which his descriptions e observations (1896), which are those of an eye- ve some value, his words are quoted *in extenso* :— ell-defined reef near the main reef (*i.e.* the western- nderlay shaft has been sunk to water level, 75 feet. evel a drive is being commenced north; here the at 18 inches of quartz; the average width of all eing about 10 inches. About 25 tons of stone lie h sample from which gave a 2 oz. prospect. The



reef strikes north 20 degrees east and underlays east at an angle of 70 degrees. On the same line of reef 80 feet to the north-west another shaft has been sunk 25 feet. Down to water level the ground on this line is a soft decomposed hornblende schist, but at water level becomes harder. On a line farther east a vertical shaft has been sunk 54 feet to cut the reef in depth, but failed to do so, and a crosscut of 10 feet had to be made. A crosscut 40 feet has also been made west to cut a rich leader prospect well on the surface. On this same line farther south, an underlay shaft has been put down 35 feet, the stone averaging eight inches. Rough sample along this line gave a 3 oz. prospect (said to be exceptionally good). Twenty tons at grass."

Another well-defined reef outcrops about 220 feet east of the last described, and three shafts have been put down upon its positions indicated on the map. It is possible that the last portions of Mr. Becher's descriptions refer to this line; the shafts, however, are at the present time absolutely inaccessible.

*Table showing the Yield of the Western Chief No. 1  
South, G.M.L. 568 (l. 258).*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1890	.	.	.	.	72·00	79·17	1·09
1900	.	.	.	.	30·00	40·00	1·33
1901	.	.	.	.	...	<sup>1</sup> 130·14	...
Total					102·00	119·17	1·16
						<sup>1</sup> 130·14	

ALEXANDER, G.M.L. 255.—This is a 9-acre lease, which adjoins the Western Chief on the south. As may be seen by an inspection of the geological map (Plate XV.), the lease is traversed by the same lines of reef as outcrop in the Western Chief and Young Australia. The principal mining operations appear to have been concentrated upon the southern extension of the most eastward of the Western Chief Reefs. A vertical shaft, stated to have been 47 feet in depth, has been sunk on this reef at a point about 100 feet from the northern boundary. This shaft is inaccessible, the late Mr. Inspector Becher's notes state: That the reef averaged from 6 to 8 inches in thickness; that the stone prospect was well throughout; that a "rough sample gave a 5 ozs. prospect." A drive had been put in to the south from the foot of the reef where the stone seemed to be increasing in size, but no particulars are available respecting it.

YOUNG AUSTRALIA, G.M.L. 261.—A 12-acre lease lying about 120 feet north of the Western Hero Group. This prospect

<sup>1</sup> From tallings.

well-defined quartz reef (which the field evidence shows the northern extension of the east reef of the No. 1 North), outcropping at an average distance of 120 feet from the eastern boundary of the lease. The "open-cut" for about 480 feet along its outcrop, and a shaft put down on it at a point about 200 feet from the northern boundary which separates the Western Hero reef from this reef, which can be followed into the lease for a distance of about 400 feet. Parallel to the reef west from the Young Australia is another reef of the same type, which can be followed with more or less certainty along the outcrop for a distance of about 460 feet from the northern boundary of the lease.

HERO, G.M.L. 253 (formerly Kushmattie, G.M.L. 455).—The most southerly of the whole group at present situated about 70 chains south from the Government reef, a well-defined though small quartz reef extends for a length of the lease, outcropping at an average distance of 160 feet from the western boundary. The reef is worked up by four shafts, all of which, however, are at present inaccessible. Just outside the southern boundary a tunnel has been put in for a few feet northwards and about a foot of stone exposed. The total length of the Western Hero reef, as exposed within the geological sketch map (Plate XV.), is about 1200 feet. The reef to this outcrops for about 100 feet to the west of the surface for about 300 feet, adjoining the Young Australia reef and near the north-west angle of the lease. It is worked out by an inaccessible shaft situated about 200 feet from the northern boundary of the lease.

*Yield of the Western Hero, G.M.L. 253 (formerly Kushmattie, G.M.L. 455).*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1896	86·00	193·00	2·24
1897	54·50	78·65	1·44
Total	140·50	271·65	1·22

HERO No. 1 NORTH, G.M.L. 254.—A fairly well-defined reef crosses the full length of the lease at an average distance of 120 feet from the eastern boundary. The reef is

*Public Opinion*, in its issues of the 6th and 13th November 1897, gives the result that during that year 134 tons of ore crushed yielded 337·15 ozs. of gold, or 2·51 ozs. per ton.

parallel to, and a few feet east of, the Western Hero Main Reef. Not much can be seen at the present time of the reef, and the shaft by which it was exploited is now inaccessible.

**TAMBOURAH KING, G.M.L. 252.**—This 12-acre lease adjoins the Western Chief on the west, and lies between it and the western tributary, which flows into Tambourah Creek at the Government Well. A well-defined reef, with a northerly trend traverses the whole length of the property, and has been opened up at one or another by four now disused vertical shafts. The reef is said to have averaged from 8 to 12 inches in width near the surface.

At the time this property was visited, no work was going on, and what seems to have been the main shaft was inaccessible. Tremaine Mill, which had been moved from the White Angel Mine near Marble Bar, is erected on the property close to the main shaft.

According to the late Mr. Inspector Becher's notes, the development on the property consisted at the date of his visit of:—

“No. 1 Shaft.—42 feet vertical.

“No. 2 Shaft.—25 feet vertical; driving south to meet No. 3; now in 12 feet, very little stone seen on the face.

“No. 3 Shaft.—25 feet vertical, with a level to connect with No. 2, now driven 25 feet; at the bottom of the shaft a good stone 14 inches in width to be seen.”

At one period in the early history of the mine, 5 tons of quartz were carted to the nearest battery at Pilbara (75 miles distant), and are said to have given a return of 6 ozs. 13 dwts. of gold per ton, from which it may reasonably be inferred that a very rich reef was met with.

The *Northern Public Opinion* of 12th February 1898, gives an account of the reef in the Tambourah King as it appeared in the lower levels of the mine, and as this is the only information as to the behaviour of the reef underground it is quoted *in extenso*:—

“From the vertical shaft in the King, the reef was struck about 40 feet, and the stone is of splendid quality, though highly mineralised, so much so that although gold shows freely in treating it with the appliances which will be available here, it hardly prove successful. . . . The country is hard and the reefs of small size—about 6 inches where struck—but getting it in hard country goes far to prove the continuance and permanency of the reefs about here, and shows too that the gold is going on as well as the ore-body. There has not been much occasion to doubt the permanency of the Tambourah Reefs, as in no less than six or seven shafts hard country has been met with, and in each case the reefs continue, whilst in some they increase in width to carry the gold down, although soon as the hard ground is met the nature of the ore alters naturally, and becomes more or less mineralised, whereas before the hard ground is reached the reefs contain comparatively little mineral and are very free to treat



Table gives the output of the Tambourah King  
which can be obtained from official data :—

*Showing the Yield of the Tambourah King,  
G.M.L. 252.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1900 . . .	56·00	112·00	2·00
1901 . . .	30·00	42·00	1·40
Total . . .	86·00	154·00	1·79

QUEEN, G.M.L. 262.—A 6-acre lease lying in  
between the Corunna and the World's Fair pro-  
perties. The surface of the lease is occupied by hornblendic and  
granitic rocks, which are everywhere inclined at very high  
angles, with a general north and south strike.

A conspicuous granite dyke occupies a considerable  
eastern area of the lease, attaining a maximum  
width of 200 feet along the northern boundary of the  
lease. A well-defined though small quartz reef, having an  
extent of 900 feet in length, lies at an average distance of  
100 feet from the western boundary of the lease, and has  
been superficially worked. Judging, however, from  
inspection of the surface, it would seem that very little  
has been raised. The reef underlies at a high angle to  
the surface and follows along the bedding (foliation?) planes of the

WORLD'S FAIR No. 1 NORTH, G.M.L. 259.—This 12-acre lease  
lies on the north of the World's Fair. There are one or two  
rocks cropping on the property, but no work seems to  
have been done upon any of them. The country rock is basic  
granite of the usual type.

WORLD'S FAIR, G.M.L. 256.—The northern portion of this  
lease is situated on the high ground to the north of and  
above Tambourah Creek. The whole surface of the lease is  
occupied by hornblende schist of the usual type, and inclined at  
angles to the east. Two well-defined reefs traverse the  
lease, but, however, only upon the eastern reef, which lies at  
a distance of 150 feet from the western boundary of the  
lease, has work been done. A fair amount of prospecting  
has been carried out upon this reef, which can be followed  
for a distance of a little over 500 feet.

A shaft has been sunk somewhere near the centre of the out-  
crop, about 450 feet from the southern boundary of the  
lease. It is at the present time inaccessible, but from the

notes of the late Mr. Inspector Becher, it appears to have been carried down 25 feet, and levels driven north and south from depth of 20 feet for an unstated length. The same writer states "Near the surface in this shaft, very rich specimen stone was found, but was apparently confined to a patch, and the owners do not apparently consider the prospects sufficiently encouraging to continue work."

So far as may be seen on the surface the reef is very thin, no place exceeding 12 inches; the stone is somewhat ferruginous, suggesting pyrites at a depth.

The files of the *Northern Public Opinion* give the following records regarding three crushings from the World's Fair in 1888, viz., July 2nd, 100 tons for 108 ozs., and 98 tons for 208 ozs., whilst on August 20th, 60 tons are stated to have yielded 351 ozs. These three crushings total 258 tons for 351 ozs., or at the rate of 1.36 ozs. per ton, which is considerably less than the official rate for the year in the following table. It may be noted, however, that this table gives the aggregate yield of the three leases held by the then World's Fair Gold Mining Company, viz., 254, 255, and 258, so that there are no means of knowing whether the whole of the gold so recorded was actually obtained from the World's Fair Lease, G.M.L. 256.

*Table showing the Yield of the World's Fair G.M. Co., Ltd., G.M.Ls. 254, 255, 258.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
1898 . . . . .	Tons. 412.00	Ozs. 505.60	Ozs. 1.22

**GOLDEN CHEERS, G.M.L. 275.**—A very large proportion of the surface of this lease, upon which little or nothing appears to have been done, is occupied by the sandy bed of Tambourah Creek, which in this portion of its course averages about 200 feet in width. There are, however, strong geological grounds for believing that the Charlie and the World's Fair Reefs may traverse the centre of the lease, but if so the outcrop can only be small and ill-defined.

**CHARLIE, G.M.L. 257.**—The main Charlie Reef, of which the World's Fair (*q.v.*) may be the northern extension, extends through the whole length of the lease, outcropping at no very great distance from the western boundary of the property.

Prospecting operations, however, appear to have been confined to a small reef, the outcrop of which can be seen entering the lease on its southern boundary at a point about 140 feet from the western boundary, forming the south-west angle of the property. An inaccessible



been put down at the southern end of the reef, or nothing to be seen at the present time.

L. 456.—A fair amount of prospecting work has been carried out on two other parallel reefs, which are at distances of 100 to 200 feet east of the main reef. The ground lying between G.M.Ls. 260 and 257, is embraced by G.M.L. 456. Shafts have been sunk on these reefs at localities which are indicated on the map, Plate XV.; but they are inaccessible, and no information is available at the present time regarding

the yield of this lease so far as can be ascertained from official data :—

*Showing the Yield of the Federal, G.M.L. 456.*

Ore Crushed.	Gold therefrom.	Rate per Ton.
Tons. 11·00	Ozs. 15·25	Ozs. 1·38

to No. 1 SOUTH, G.M.L. 260.—A 6-acre lease adjoining Australian No. 1 North, G.M.L. 341 on the west. Although well-defined white quartz reef outcrops are present on the property at an average distance of about 100 feet from the western boundary of the lease. The reef underlies the ground at a high angle, as is the case with most of the reefs in the neighbourhood. What may be called the extension of this reef appears as a short distance northwards, where it terminates at a point on the northern boundary distant about 150 feet from the peg forming the north-west angle of the lease. This reef, which is remarkable for its longitudinal strike, can be followed northwards right through the Charlie, and is at a distance of about 1500 feet.

AUSTRALIAN No. 1 N., G.M.L. 341 (formerly Old No. 1 L. 465).—This 9-acre lease adjoins the Young lease to the north and the Alexandra on the east. Virtually no work has been done upon the ground. The Young lease enters the lease at the south-west angle of the Young lease and can be followed to a point about 500 feet north, where it is crossed by a dyke, which traverses the surface, crosses its strike at right angles to the strike of the reef. North of this dyke is a well-defined band of laminated quartzite, with secondary mineralization appearance, and can be followed without interruption to the northern boundary of the lease and for a distance of about 1500 feet farther.

On June 1897, of the *Northern Public Opinion*, gives a return for that year showing 21·00 ozs., or at the rate of 1·07 oz. per ton. It is probable that this is the yield in the official returns from Sundry Claims in 1897.

Table showing the Yield of the Young Australian No. 1  
(formerly the Old Australian, G.M.L. 465).

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	51·50	70·10	1·36

QUARTZ CLAIM 148 (McGrath and Anderson).—A quartz claim the exact situation of which is not now identifiable, produced in 1904, 43·71 ozs. of gold.

SUNDRY CLAIMS.—The following figures arranged in a tabular form annually give the yield of the various claims which have been held at different times, but which cannot be located on the map at the present time. It is more than likely that some of the claims embraced the areas covered by the leases referred to on the previous pages.

Table showing the Yield of Sundry Claims at Tambourine.

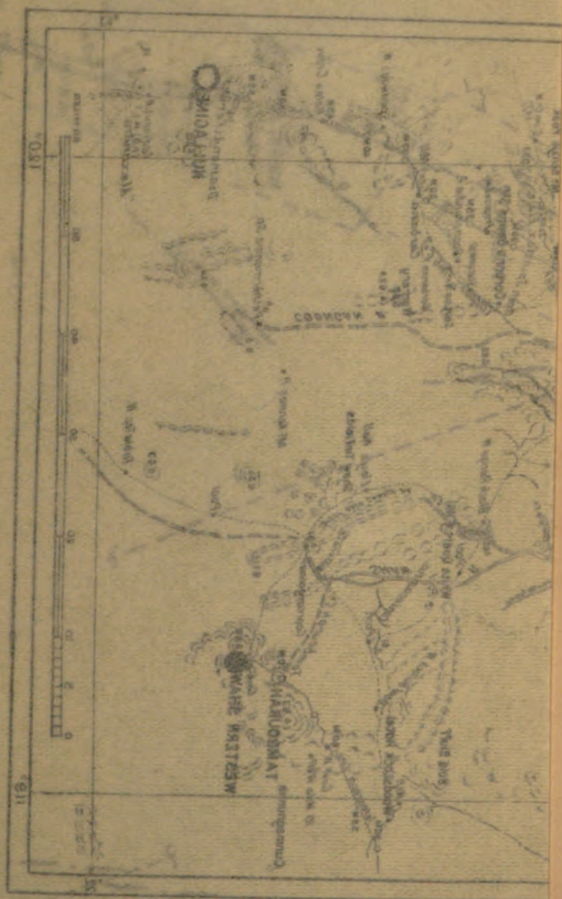
Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Gross Ozs.	Ozs.
1897 . . . . .	23·00	33·65	1·46
1898 . . . . .	128·75	{ 197·40 1 20·00	1·53
1899 . . . . .	436·50	{ 590·95 2 50·00	1·36
1900 . . . . .	51·00	{ 89·20 2 215·00	1·74
1901 . . . . .	...	2 25·00	...
1902 . . . . .	...	Nil	...
1903 . . . . .	...	Nil	...
1904 . . . . .	...	2 43·71	...
1905 . . . . .	...	Nil	...
Total . . . . .	639·25	{ 911·20 1 20·00 2 333·71	1·42

1 Dolled and specimens.

2 Alluvial.

3 Fine ore.







2

—



able showing the Yield of the Tambourah  
Reefs up to the end of 1905.

	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
. .	35·00	<sup>1</sup> 21·60	·61
. .	11·00	15·25	1·38
. .	88·00	208·50	2·36
. .	140·50	271·65	1·22
. .	51·50	70·10	1·36
. .	...	<sup>2</sup>	
. .	...	<sup>3</sup> 43·71	
. .	639·25	<sup>4</sup> 1,264·91	1·42
. .	86·00	154·00	1·79
<sup>5</sup> . .	34·00	37·68	1·10
. .	654·00	763·90	1·16
I S . .	102·00	<sup>6</sup> 249·31	1·16
. .	412·00	505·60	1·22
. .	2,253·25	3,606·21	1·60

## GENERAL

server cannot fail to be struck with the  
e district considering the short period of its  
ber of shafts in close proximity, upon one of  
Western Chief, seem to imply that prospecting  
ly carried out in the most judicious manner  
unnecessary work was done in consequence.

umber for mining purposes are not abundant,  
doubt that careful search would result in the  
in the vicinity to meet the requirements of a  
years.

ascertained there seems to be a fair water  
at a shallow depth, but whether such would  
withstand a constant draft upon it, there

### N.—Western Shaw

ological Sketch Maps, Plates XVI. and XVII.)

e of Western Shaw lies about 5 miles to the  
arah, and like it is situated on the old mail  
At one period of its history, Western Shaw

ly included under the Western Chief Mine.

ollied and specimens.

of dollied and specimens and 333·71 ozs. of alluvial.

unknown.

ozs. from tailings.

was connected with the main telegraph system of the State. The relative position of Western Shaw is shown on the geological sketch map, Plate XVII., which also indicates in a general way the situation of the field with respect to the boundary of the intrusive granite, which is continuous from Tambourah.

The backbone of Western Shaw is formed of several prominent rugged and broken razor-backed ridges, which rise to heights of 200 feet above the general level of the country, and form very conspicuous features in the landscape. These ridges trend generally north and south, and it is upon the slopes of the western side that the principal prospecting and mining operations have hitherto been carried out.

## HISTORY

The history of Western Shaw as a mining centre appears to have commenced with the rush of 1891, and an immense amount of alluvial gold was won by the dryblowers in the many creeks which traverse the country. As a reefing centre, however, its history dates from 1894, and as has been the case with most of the North-West mining fields, the district has had a somewhat chequered career.

The late Mr. Becher, at one time Acting Inspector of Mines for the Northern Goldfields, in his report to the Government on the district for the year 1894-5, remarks:—

“The Western Shaw, although a field which has been little known for many years for its alluvial gold, is one of the new fields coming quickly to the fore. The general character of the country lying on the outskirts of the granite is most attractive on account of its rugged nature and geological conditions. Immense quartz veins, quartz jasper dykes form the crests of ranges of diorites, of slates, and schists, all having a general uniform bearing on a slightly west of north. The strata are much upheaved and tilted to the westwards. Many large well-defined and continuous reefs can be seen, and a considerable amount of work is being done on good stone. During the year several rich finds have been made.”<sup>1</sup>

In his report for the following year, Mr. Becher states that

“At Western Shaw considerable progress has been made by the Imperial West Australian Corporation, who have erected a 10-head battery on their property.”<sup>2</sup>

The Warden in his report on the Pilbara Goldfield for the year 1895 mentions:—

“A battery is now being erected at Western Shaw, and a few parcels of stone that have as yet been crushed for the benefit of the owners themselves, and for some of the surrounding leaseholders.”

<sup>1</sup> Annual Report of the Department of Mines for the year 1896. Perth: By Authority, 1896, p. 30.

<sup>2</sup> Ibid., for the year 1896. Perth: By Authority, 1897, p. 36.



returns and proved the properties to be more

for the following year... den mentions that  
the mining centre among... persons, that  
ing leases in ex... 78 acres, and  
ny, and that... was 1032 ozs.,  
illing of 1140 to...  
tion of Western... appears in any later  
he Depart...  
ffered a gradual decl... until at the present  
y aban...  
**GEOLOGICAL SKETCH MAP**  
**PILBARA & WESTERN SHAW**  
PILBARA G.F.



PLATE 17.

The Hon. R. G. M. A. M. A.  
Minister for Mines

GEOLOGICAL SKETCH MAP

**PILBARA & WESTERN SHAW**

PILBARA G.F.

BY  
**A. Gibb Maitland**

GOVERNMENT GEOLOGIST

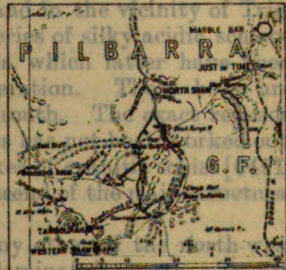
H. W. B. TACBOT

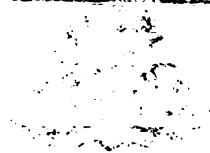
FIELD ASSISTANT

1905

Scale of Miles  
EXPLANATION OF COLOURS AND SIGNS

- ALUMINUM
- IRON
- COAL
- QUARTZ
- DIAMOND
- EMERALD
- OPAL
- PEARL
- SPINEL
- TOPAZ
- ZINC
- COPPER
- SILVER
- GOLD
- PLATINUM
- DIAMOND
- EMERALD
- OPAL
- PEARL
- SPINEL
- TOPAZ
- ZINC
- COPPER
- SILVER
- GOLD
- PLATINUM

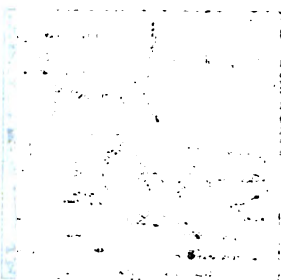




THE HISTORY OF THE CITY OF LONDON

BY JOHN STOW

THE SECOND EDITION, REVISED AND CORRECTED BY JOHN STOW



1633



returns and proved the properties to be more for the following year, the Warden mentions that the mining centre amounted to twenty persons, that mining leases in existence totalling 78 acres, and company, and that the gold yield was 1032 ozs., milling of 1140 tons of stone.<sup>2</sup> Mention of Western Shaw appears in any later report of the Department of Mines. The field suffered a gradual decline, until at the present time it is abandoned.

### GENERAL GEOLOGICAL FEATURES

Geological features, Western Shaw presents many points of resemblance to the mining centre of Warra-

formations of the area embraced by the map, Plate XVI., are represented by a series of greenstone schists, which form the southern boundary at Tambourah.

East of the greenstones and in the vicinity of Trig. 1 are succeeded by a series of silky acidic schists, and fine conglomerates, which latter have been subjected to considerable dynamic alteration. These beds are generally north and south. The exact relation of the greenstones has not been worked out. They are traversed by dykes of granitic schist [6491] in a general parallelism to the trend of the main structural district.

The field are like many other of the north-west traversed by veins of laminated quartz. Two of these have been laid down on the map with a degree of accuracy. One very conspicuous band of the length of the area mapped, viz., about  $2\frac{1}{2}$  miles, is made up of what may be called the main auriferous zone, as is indicated by the long line of leases. The zone is traversed by faults, one of which has a displacement of about 600 feet. This fault, which is on the surface, and appears to be a reverse fault, has a trend north-west and south-east.

Intercourses in the district are, as may be seen by the map, occupied by a varying width of alluvium, which have been very extensively worked, and, consequently, a fair amount of alluvial gold would appear to be obtainable therefrom. So far as has at present

<sup>2</sup> Report of the Department of Mines for the year 1897. Perth: By Authority, 1897.  
57-73. Perth: By Authority, 1905.

been ascertained, the alluvial deposits do not attain any thickness.

A Government Well has been sunk in the centre of the flat, a little to the north of the 75-mile post on the old telegraph line, to a depth of 37 feet, and yields a supply of about 400 gals of good, fresh water per day. There is no information as to the thickness of alluvium in this well.

There are several well-defined quartz reefs in the area investigated, the longest of which has a continuous outcrop about 1200 feet; whilst another to the east is represented by well-marked veins, connected by thin threads of quartz, and said to be about 2500 feet long.

From what can be seen at the present time, the quartz seems to conform to the foliation planes of the schists, &c., and perhaps, on that account, be best described as bedded veins. The quartz is generally very white and milky in colour, and is occasionally very honeycombed, due to the decomposition of the pyrites.

The gold is said to have been very coarse, and as might have been expected, occurred most plentifully in the honeycombed quartz.

#### THE ORE DEPOSITS AND MINES.

No mining work of any description was being carried on at the date of my visit to the district, though such mines as were open to inspection were visited, and full descriptions of them are given below.

When operations were in full swing, seven of the thirteen mines in existence on the field were held by the Imperial W.A. Company, and a considerable amount of development work had been done. In order to facilitate the company's operations, tracts of 35 chains and 70 chains in length had been laid down from leases 214 and 213 to the battery site on the western boundary, G.M.L. 291. For convenience of description the mines and workings are described in geographical sequence, commencing at the northern end of the field.

TRAFALGAR, G.M.L. 338 (*vide* Plate XVI.).—This 12-acre mine is situated about  $1\frac{1}{2}$  miles north of the Government Well on the eastern side of the range which forms the main axis of the W. Shaw.

Two very small quartz veins, striking north-east and dipping to the west, had been opened up by trenching; the veins averaged about 8 inches in thickness. A vertical shaft 75 feet deep had been sunk, and at 45 feet levels driven 30 feet north and south respectively.

The two reefs mentioned above are stated to have been exposed on each wall, and their average thickness proved to be about 8 inches. A second shaft had been sunk to a depth of 40 feet.



Further to the south, but no particulars concern-

the veins in this lease is stated to have been contained small quantities of iron and copper

able gives the yield of this property, so far as from official data :—

*the Yield of the Trafalgar, G.M.L. 338.*

	Ore Treated.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
: :	6·00	36·00	6 00
: :	24·00	54·00	2·25
. .	30·00	90·00	3·00

L. 340.—A 12-acre lease lying some little of that last described is traversed by four red quartz veins encased in a talcose and westernmost reef, which is by far the longest length of about 450 feet, is the one upon which done. Two vertical shafts, connected by a have been sunk to depths of 50 and 40 feet the reef, which is stated to have attained an about 1 foot 6 inches, and dipping at a high at the time the mine was at work and visited of Mines, Mr. Becher, there were about 150 waiting crushing. No official record, however, yield of the stone, which is in all probability Sundry Claims from the Tambourah district, page.

W.A. CORPORATION, LTD.

Leases . . { 291, W. Shaw No. 1 N.  
214, W. Shaw Reef.  
290, W. Shaw No. 1 S.  
428, General Gordon No. 1 N.  
230, General Gordon.  
215, W. Shaw Consolidated  
213, W. Shaw Extended.  
124,

REEF, G.M.L. 214.—The principal workings have been carried out on two short parallel near the summit of the hill on the eastern property. These two reefs have outcrops about and lie about 20 feet apart. The reef had

from *Public Opinion* for June 5th, 1897, give the yield as being rate of 3·46 ozs. per ton.



been worked by a tunnel driven on a bearing of 59 degrees minutes from near the base of the western side of the reef. The total length of the tunnel is 262 feet, and struck the reef at 200 feet from its mouth; the first few feet in the tunnel expose what appears to be a compressed greenstone, which, however, gradually gives place to the normal rock. From the tunnel the reef has been carried 103 feet north and 80 feet south respectively. The reef averages about 12 inches in thickness, and in the south drive proved to be very large in places. The quartz of the reef is of a characteristic white colour, and carries a certain amount of gold on the casing. The tunnel has been carried 62 feet east beyond the reef, and ends in a small laminated quartz vein which trends to the westward at an angle of 70 degrees. An underlay of 100 feet in depth has been sunk at a spot indicated on the geological map, Plate XVI., and connects with the drive to the north of the tunnel. A considerable amount of stoping has been done on the reef, so far as may be judged by the present condition of the workings. Very rich specimen stone is said to have been found in frequent occurrence in the mine. A tramway had been laid from the tip at the mouth of the tunnel to the battery.

To the west of this lease, and between it and the alluvial flat on the main creek, are five quartz reefs, upon which, judging from the condition of the surface, a fair amount of prospecting must have been done; there is, however, no information as to the results of this.

**WESTERN SHAW No. 1 SOUTH, G.M.L. 290.**—The creek which traverses this lease is traversed by a persistent vein of laminated quartz which extends over the whole length of the leases; which, in its south-western portion is occupied by the wide alluvial flat. This has yielded such large quantities of gold in the early days of the field. The south-west angle of the ground is occupied by a marked quartz reef which trends north-west and dips west at a high angle. This reef abuts against the reverse fault, and traverses the adjoining lease to the south.

**GENERAL GORDON No. 1 NORTH, G.M.L. 428.**—A small lease adjoining the one previously described on the south. An important structural feature of this lease is the reverse fault which traverses its whole extent in the position indicated upon the geological map, Plate XVI. The quartz reef, which enters the property on the north at a point about 130 feet from the western angle, turns sharply southwards on approaching the fault, against which it is abruptly truncated. A tunnel has been driven in for a total distance of 72 feet, on the following bearing: 120 degrees, 48 feet, and 245 degrees, 24 feet; 31 feet from the mouth of the tunnel the reef was met with, but disappears a few feet beyond the fault. The late Mr. Inspector Becher, who sampled the reef, stated in his official report that it did not yield good prospects. An excellent view of this reverse fault, and the curving of the foliation (? bedding) planes in its proximity is to be obtained

to the east of the creek, on the eastern boundary

COON, G.M.L. 230.—This 12-acre lease adjoins that of the General Gordon on its southern boundary; the centre of it is traversed by the laminated quartz which are associated a few irregular veins of quartz. Inspectors are stated to have obtained some good gold from the outcrop of one of these veins outcropping on the hillside. On the summit of the hill and to the west of the laminated quartz, a very small rich (residual) gold was met with. The patch was square, and occurred in close proximity to one of the quartz veins, to the disintegration of which the gold is to be ascribed. A shaft has been sunk to a level on a vertical quartz reef, and a crosscut driven from these were inaccessible. A tunnel has been driven up the hill for a distance of about 160 feet at a distance to the south of the shaft described, but it is not complete; it is, however, asserted to have been driven

NEW CONSOLIDATED, G.M.L. 215.—This is a 12-acre lease adjoining the General Gordon on its southern boundary; it is traversed throughout its whole length by the belt of quartz which forms the summit of the ridge upon which it is situated.

On the southern boundary of the lease, at a point shown on the sketch map, Plate XVI., is a quartz reef of from 12 to 18 inches in thickness; this, which underlays east at an angle, has been opened out to a depth of about 12 feet. It is of the characteristic white colour, gradually increasing in thickness from the surface to the bottom of the reef, where it is abruptly cut off by a strike fault. A tunnel, which has been opened out in the adjoining lease, traverses the southern portion of the property for about 300 feet north of the southern boundary, at which point it appears to peter out on the surface. This main reef is worked by means of two shafts and a tunnel, put in along the line of the two leases, in an easterly direction, near the western fall of the ridge upon which the tunnel, which intersects the reef at 58 feet, shows the following section: Schist, 27 feet; quartz, 16 feet; and schist, 15 feet. The main reef at the surface is 18 inches in thickness; it has been exploited by a tunnel which has been carried north along the reef for a distance of about 164 feet, where it intersects the reef, wherever seen, averages about 18 inches, and in some places it attains a thickness of over 4 feet. A tunnel, sunk on the reef the whole way, connects the two shafts, whilst a second shaft of 75 feet intersects the reef from the tunnel. In this shaft a level has been



driven on the reef 83 feet north from a point 40 feet below the mouth of the shaft, but such was inaccessible to me.

At a point near the western boundary of the lease, and 440 feet from the northern boundary, is a tunnel, which has been driven westward and connects with a shallow vertical shaft at the old tram-line. The workings, however, were inaccessible.

**WESTERN SHAW EXTENDED, G.M.L. 213.**—This 12-acre lease is the most southerly of the group owned by the Imperial Mineral Corporation Co., Ltd. The surface of the lease is occupied by greenstones and their cleaved and foliated derivatives. A line of quartz, the centre of the property is traversed from end to end by a series of laminated quartz, which forms the main axis of Western Shaw. It dips west at an angle of 75 degrees. The main reef extends along the property on the northern boundary, and can be followed for a distance of 900 feet, the southern end of it being represented by a mere thread of quartz. The reef has been traced from the tunnel alluded to in the description of the lease on the north. From the face of the tunnel a drive has been carried south for a distance stated to be 300 feet. This was, however, inaccessible to me for a distance of 253 feet. An adit 30 feet in depth connects with the surface at a point 30 feet from the face of the tunnel, and a second, 70 feet in depth, is 153 feet from the same spot. The reef is showing for the whole length of the drive, and, although it varies greatly in thickness, it may be said to average about 18 inches. The quartz of the reef is made up of almost pure white; it carries a little pyrites, galena, and more or less coarse gold. The original prospectors of the reef are stated to have obtained very good specimens of men stone along the outcrop, which may be held accountable for the amount of surface work done upon it. A large quantity of quartz obtained from the reef is lying at the mouth of the tunnel and was not put through the battery by the owners of the property.

The following table gives the yield of the Imperial West Australian Corporation's property, so far as can be deduced from official data :—

*Table showing the Yield of the Imperial West Australian Corporation, Ltd., G.M.Ls.*

Year.	Ore Crushed.	Gold therefrom.	Ratio per Tonnage
	Tons.	Ozs.	Ozs.
Prior to 1897 . . . . .	18·50	19·00	1·0
1897 <sup>1</sup> . . . . .	1,190·50	1,060·89	·89
1898 . . . . .	12·00	34·65	2·89
1900 . . . . .	...	2 31·75	
Total . . . . .	1,221·00	1,114·54 2 31·75	·89

<sup>1</sup> For detailed returns for this year, see next page.

<sup>2</sup> From tailings.

the *Northern Public Opinion* of January 16th, and June 5th of 1897, give the following detailed year:—

Month.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
. . .	140·00	522·00	3·72
. . .	80·00	253·00	3·16
. . .	240·00	474·00	1·97
Total . . .	460·00	1,249·25	2·71

### GENERAL

be ascertained from the official figures, the following is the gold yield of this centre, other than that of alluvium, of which there does not appear to have been any record, such alluvial gold as has been obtained has been included under the general yield of the district as defined by the authorities.

#### *Yield of the Gold Yield of the Western Shaw Reefs.*

Reef.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
s . . .	1,221·00	1,146·29	·91
. . .	30·00	90·00	3·00
Total . . .	1,251·00	1,236·29	·98

little firewood within the vicinity of the mines; for mining and building purposes would have to be transported several miles. There is no battery for crushing the ore, the ore being raised from any of the reefs.

#### O.—North Shaw

(With a Map, Fig. 52.)

of visiting North Shaw presented itself, but in the two previous reports may contain information of a locality where mining operations are being carried out, the following unpublished description by Dr. Becher, at one time Inspector of Mines for the district, is given.

So far as can be ascertained, the total gold yield in from this centre has been, up to the close of 1905, as follows

Alluvial . . . . .	7.53 oz.
Dollied . . . . .	567.06 "
In addition to 674.72 ozs., the result of the milling of 351.45 tons	

"The North Shaw district lies to the south-west of Bar, 36 miles by horse track or 40 miles by road. The reefs lie to the south of the Callina Creek about 2 miles from the junction of Callina Creek and Shaw River.

"Low hills and an extensive flat contain the reefs now worked; most of the reefs only show their line of outcrop and there, the main exception being the Leviathan line, is a big white quartz reef outcropping boldly for a couple of miles.

"There is an abundant supply of good timber, and permanent pools and soaks in the river beds. A Government lease has been sunk on the flat near the Callina Lease. The reefs are kindly. The reefs mostly carry a lot of mineral (copper, some galena and silver ores). In the old Leviathan vein gold has been obtained, but most of the gold in the mill is quartz is of a fine nature.

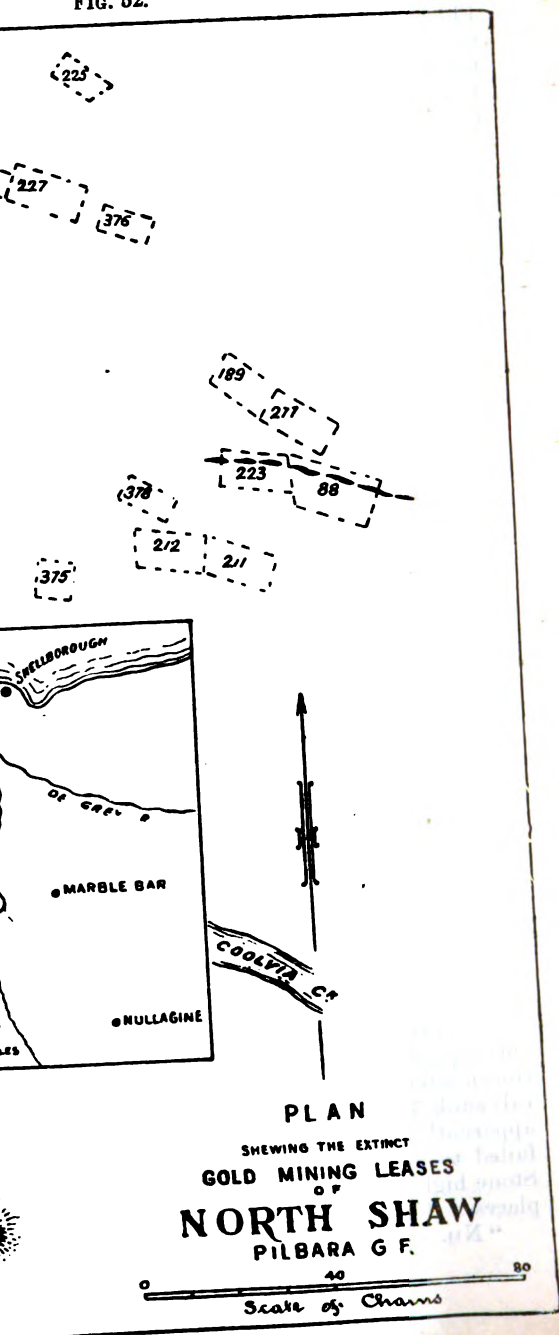
#### THE MINES.

"ELDORADO, G.M.L. 88.—Situating about three-quarters of a mile from Government Well. This is the oldest mine of the district having been worked for over two years by various parties. The line of reef does not outcrop consistently, only showing here and there on this and the adjoining (west) lease. Upon this reef is bigger than elsewhere, being in places quite 6 or 7 feet wide. The stone is mineralised with iron, copper, and silver ores, but the quality of the gold is low in value. Some handsome nuggets have been obtained, and a trial crushing of 4 tons gave a yield of 7 ozs. per ton. A considerable amount of work has been done but the property became liable to forfeiture owing to non-compliance with the labour covenants by the Eldorado Company of Melbourne. The reef is practically vertical, with perhaps at least underlay south, the course being east and west. A No. 1 shaft has been sunk 60 feet and levels driven at 30 and 60 feet. There is now 25 feet of water in the shaft; we were therefore unable to examine lower level. At the 30 feet level, on a short drive of 18 feet west, the reef apparently pinches out and should make again. Eastward a drive of 40 feet connects with No. 2 shaft, a big body of stone being driven on. The reef is carried on eastward some 30 feet on the reef. Some tonnage has been taken at grass. Should the forfeiture be approved, a battery will be erected.

"ELDORADO WEST, G.M.L. 223.—Royer, Quinn, and others. 12 acres. Two men; partial exemption. Situated west of



FIG. 52.



joining the Eldorado (late). The reef is smaller than Eldorado, but yields good stone all through. It retains its mass and mineralised character. Some of the stone contains iodargyrite and proustite shows beautiful free gold. Native copper has also been found in this line of reef. The eastern shaft is 100 feet in depth and a drive is being put in westwards towards the shaft. The reef averages 2 feet in width with good walls. The western shaft, about 50 feet away, is down 40 feet. A drive of 12 feet has been made eastwards at the 33 feet level to connect with drive from No. 2 shaft. A short drive has also been made west. About 100 tons at grass awaiting crushing. The hillside (south) above the main line of reef, 2 other parallel lines of reef have been prospected superficially, yielding encouraging prospects. These reefs apparently underlay north at an angle of about 60 degrees, and should therefore meet the main reef at depth. The country is diorite or metamorphic schist on the walls.

"THE BERTHA, G.M.L. 431, 12 acres (W. McPhee).—A lease taken up, situated adjoining Eldorado. The reef, which is apparently of considerable width, is a cross line to the Eldorado line of reef, having a north and south course and underlaying the Eldorado. The stone exposed in a 10-foot hole on the underlay is of encouraging character, and is mineralised with lead and iron. In washing dish prospects, carbonate of lead remains as a residue occasionally.

"AURARIA, G.M.L. 394, 6 acres (Wm. Wye).—Situated on a plain about three-quarters of a mile west of the Government mine, half a mile from Callina Creek, and  $1\frac{1}{2}$  miles from junction of Callina Creek and Shaw River. The reef outcrops only here and there but the line is marked. Prospecting trenches have been sunk exposing a well-defined reef of 12 inches to 2 feet. A shaft is down 46 feet on the underlay, the reef having an east and west course and underlaying north at an angle of 65 degrees. The walls are true and consist of an altered slate hanging wall country with pyritic intrusions and a metamorphic schist footwall country. The reef is hard. The shaft is well propped and has good ladders. The reef is mineralised with iron and a little copper. Average sample of ore stack gave  $1\frac{1}{2}$  ounces prospect. About 20 tons at grass. The reef from reef exposed in prospecting trenches gives prospects of 1 ounce.

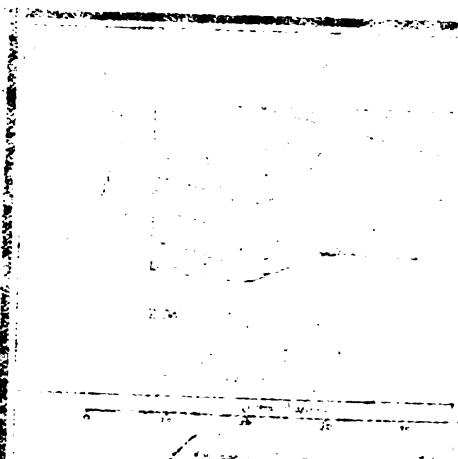
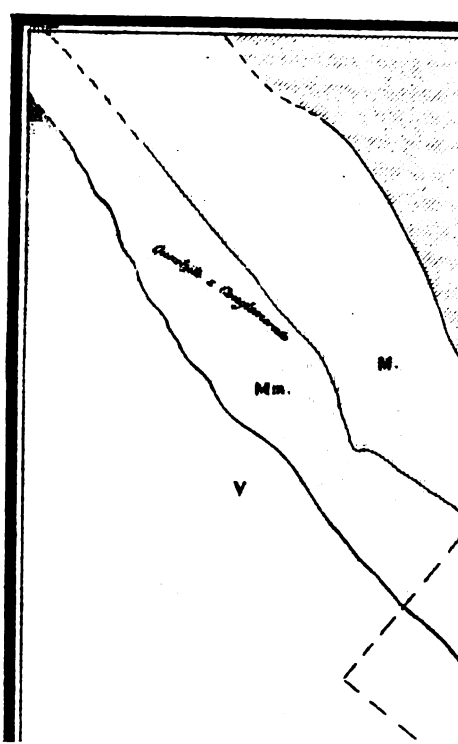
"STRUCK OIL, G.M.L. 375, 6 acres (W. Wye).—Situated on a plain three-quarters of a mile south-west of Eldorado. Course of reef (inconsistent) east and west, underlay slightly south. Shaft sunk 30 feet. At 15 feet level reef cut right off horizontally, apparently faulted across from south side. Short crosscut failed to pick up. At bottom level, drive 13 feet, but no reef. Stone highly mineralised and prospecting well; trencched in places. Consider it to be only a superficial small gash vein.

"NIL DESPERANDUM, G.M.L. 378, 6 acres (Wye and Wall)





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st of Eldorado West, about half a mile distant. A y mineralised (copper) reef of about 8 inches to 18 flatly around the base of low hill; probable course and underlay north. A general sample yielding 2 A little trenching done. Another parallel reef side; similar stone. Shaft (underlay) just com- one is about 12 inches to 18 inches in thickness.

A boldly-marked line of reef some 2 feet to 12 feet l extending for a couple of miles, lies parallel to e Eldorado. It is known as the Leviathan, from e abandoned leases taken up formerly on the west a patch of some 500 ozs. of gold or more was worked , around the reef, some rich alluvial had been reef is mostly of very fine quartz. A small shaft n the old Leviathan lease area, but nothing is now is line of reef."

### P.—Just-in-Time

*With a Geological Sketch Map, Plate XVIII.)*

centre of Just-in-Time, which was the scene of a 92, is situated about 8 miles south of Marble Bar, tributaries of the Coongan River; its position in other mining centres is indicated on the geological he Pilbara Goldfield, which forms the frontispiece

e gold yield of Just-in-Time has been small, erest attaches to the locality on account of the its auriferous deposits to the gold-bearing con- fullagine, which have been fully described in a

### GENERAL GEOLOGICAL FEATURES

upon which operations have been principally he slopes and summits of a relatively narrow and e which trends generally north-west and south-east. l features there are two distinct geological forma- n to the recent superficial accumulations) in the

an older series of schists and allied rocks, and a series of grits, quartzites, sandy shales, and con- glomerate, together with bedded lavas, the whole being the equivalent of the Nullagine Series, which is so extensively developed in the north- west division of the State.

rv., Bulletin 20. Perth: By Authority, 1905, pp. 12-52.

The schists and allied rocks form part of the zone which embraces Yandicoogina, Warrawoona, Marble Bar, and Talga Talga, which have been fully described in former reports.<sup>1</sup> The schists developed in the vicinity of Just-in-Time were not examined in detail; they were found, as was the case elsewhere in the district, to carry quartz reefs, which, however, did not appear to be of great extent.

Approaching Just-in-Time from the south-west, by way of Cooglegong, a complete section of the Nullagine Series is obtained. The beds in this locality cover a width of about 21 miles on the surface.

After leaving the granite, which forms the staple formation from Cooglegong to the Black Range Well (geological sketch map of Pilbara—Frontispiece), a coarse conglomerate or boulder makes its appearance in the bed of the river at the crossing. This conglomerate contains large boulders of granite of the Cooglegong type. From the Black Range Well the road to Just-in-Time trends generally north-east, and traverses grits, &c., with occasional relatively small patches of granite and schists, which the irregularity of the floor upon which the Nullagine Beds were laid down caused to rise to the present surface of the ground and protrude through the newer beds. Some distance from the old Black Range Well, and a little distance from the new well, which had recently been sunk, and the position of which is not indicated upon any of the published plans, the sedimentary rocks give place to vesicular lavas, &c., of the type common to the series elsewhere. At Glen Herring, a very coarse conglomerate and quartzite, dipping at 15 degrees to the north-east, makes its appearance in the lofty range which abound in the vicinity. The conglomerate at the base is made up of pebbles and boulders of the jaspideous quartzite which forms the picturesque band of rock at Marble Bar.<sup>2</sup>

In the Gorge at Glen Herring the conglomerate was seen to be overlaid by lavas, &c., which were faulted against the quartzite as shown in Fig. 53.

As careful examination of the Glen Herring section at an early short time at my disposal admitted, suggested the possibility of the conglomerate being the base of the Warrawoona Beds, though it must be admitted that there is little either for or against this view. From Glen Herring to Just-in-Time, the whole country in the vicinity of the route is occupied by the lavas and associated sedimentary rocks of the Nullagine Series.

At Just-in-Time itself, as may be seen by an inspection of the geological section (which is upon the same scale as the map), the Nullagine Series is represented by about 350 feet of grits, quartzite, sandy shales, and conglomerate, together with a great thickness of bedded lavas. At the base of the series, and resting upon the old

<sup>1</sup> Geol. Surv., Bulletin 15. Perth: By Authority, 1904, pp. 44-51, 61-72; and Geol. Surv., Bulletin 20. Perth: By Authority, 1905, pp. 57-105, 105-120.

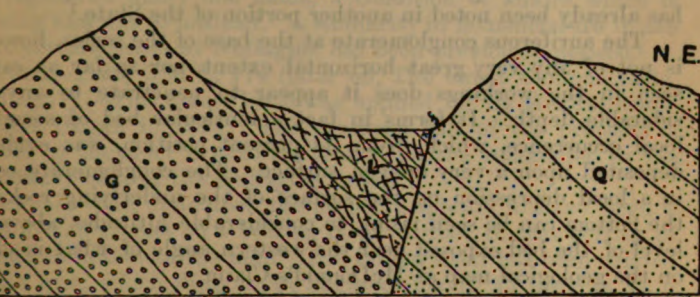
<sup>2</sup> Geol. Surv., Bulletin 20. Perth: By Authority, 1905, p. 107.



, is a very ferruginous conglomerate [6496] which varies from  
 up to 5 feet 6 inches in thickness.

In many respects the auriferous conglomerate resembles the  
 ferruginous bands which form such an important feature in the  
 as developed at Nullagine itself. The conglomerate consists  
 of boulders and rounded and subangular fragments of the  
 surrounding underlying rocks, together with occasional pebbles of  
 pre-existing conglomerate. The matrix of the conglomerate is  
 hard and siliceous, due to the deposition of secondary silica, &c.  
 Some portions of the conglomerate [6496] contain a sufficient  
 quantity of hematite and limonite, in the form of the cube, the  
 octahedron, and the dodecahedron, to give a distinctive character  
 to the rock. Some of the faces of the crystals are striated in the  
 direction common to pyrites. The iron ore is virtually confined to

FIG. 53.



Section at Glen Herring Coongan River Pilbara G.F.

*Conglomerate*      *Q*      *Quartzite*      *L* *Lavas*      *f* *Fault*

thin lenticular bed at the base of the series, though a very small  
 quantity occurs in the stratum, on a higher horizon at the mouth  
 of the tunnel in G.M.L. 114. A portion of the very ferruginous  
 conglomerate [6496] yielded, as the result of an assay in the Survey  
 Laboratory, merely a trace (*i.e.* less than half a pennyweight) of  
 gold per ton. Though a careful search was made, no free gold  
 could be detected in any of the conglomerate at present open to  
 examination.

The late Mr. Inspector Becher, who visited the district in 1896,  
 when active operations were going on, makes the following important  
 observations:—

The lode 'freezes' very tightly on to the walls, and as the  
 gold is found near and on the footwall, a few inches of foot-  
 wall is taken out with the ore in order not to miss any gold; in  
 fact I have seen a specimen showing gold in the footwall stone  
 from a few inches into it, away from the lode. . . . The

gold occurs as waterworn particles and grains sometimes attain as much as several ounces in weight."

This latter observation is of interest and importance, in that it would seem at first sight that some at any rate of the gold in the conglomerate is of a detrital character and origin. It is of course conceivable from the nature and mode of formation of the conglomerate that a certain quantity of detrital gold may occur in it, but from the fact that many of the crystals and fragments of iron ore occur in a more or less rounded form, I am inclined to believe that the rounding of the gold also is due to other causes than attrition, and that it is of secondary origin. The conglomerate must have been of such a nature as would readily permit of more or less free circulation of mineral-bearing solutions, while the underlying schists are practically impermeable.

The occurrence of secondary gold in the zone of decomposition of the bed rock, upon which the auriferous detrital deposits have already been noted in another portion of the State.<sup>1</sup>

The auriferous conglomerate at the base of the series, however, is not of any very great horizontal extent, nor so far as can be seen in the workings does it appear to penetrate to any considerable depth. It forms in fact a lenticular bed of somewhat local occurrence, which, from its present position, was evidently deposited upon a very uneven surface. The conglomerate occurs in a local depression on the surface of the underlying rocks, the bottom of which can be seen rising to considerable altitudes above the level of the bed exposed near the western angle of what is shown on the geological map as McDonald's Claim.

The creek and its tributaries, which takes its rise in the escarpment of the conglomerate and flows across what was originally G.M.L. 164, has been the scene of some vigorous prospecting. This creek is stated to have yielded a fair quantity of alluvial gold, of which unfortunately there appears to have been no separate record kept. The amount derived from this source is probably included in the returns showing the yield of the Marble Bar district as defined by the Mines Department. Most of the gold from this source owed its origin to the disintegration of the conglomerate itself.

The sedimentary beds of Just-in-Time are covered, as may be seen by the geological sketch map and section, by a considerable thickness of andesitic (?) lavas [6498, 6499], many beds of which are vesicular and amygdaloidal. In their general character and behaviour, they agree very closely with those which are exposed in the river for some miles above the township of Nullagine.<sup>2</sup>

No volcanic focus from which these lavas emanated was noted within the small area examined. The beds, however, cover a very wide extent of country in the vicinity of Just-in-Time, and in

<sup>1</sup> Annual Progress Report of the Geological Survey for the Year 1899. Perth: By Authority, 1900, pp. 9 and 43.

<sup>2</sup> Geol. Surv., Bulletin 20. Perth: By Authority, 1906, pp. 23, 24 and 26, 27.



possible that much more detailed search than has at present been carried out would lead to the discovery of the source from which these beds were derived.

### THE MINES.

No work of any description was being carried on at the date of my visit, and operations had evidently ceased some years ago; nevertheless all the accessible workings were visited and carefully examined. For descriptive purposes it is convenient to deal with the various workings within the boundaries of the leases existing at the date operations were in full swing; the positions of these are shown upon the geological map, Plate XVIII.

It may be noticed that the nomenclature of the properties is very much to be desired in that two distinct leases have been registered under one name, a condition of affairs which is confusing and apt to mislead. A similarity in nomenclature in the case of certain leases at Nullagine has been previously noticed.<sup>1</sup>

**JUST-IN-TIME, G.M.L. 114** (later on, **The Great Cement Lode, G.M.L. 251**).—This 6-acre lease was applied for by Messrs. Dunsford and Hogan in 1894. The northern half of the property is composed of the older crystalline rocks, and the remainder by the younger beds of the Nullagine Series.

The only work done upon the property appears to have been a tunnel driven 48 feet on a bearing of 41 degrees, in that portion of the lease indicated on the map. The tunnel itself has been carried through grit, which dips at an angle of about 35 degrees in a direction of south 50 degrees west. At the mouth of the tunnel is a bed of conglomerate [6497] about 2 feet in thickness, of a somewhat similar type to that which forms the base of the series G.M.L. 165, but not nearly so ferruginous.

**JUST-IN-TIME, G.M.L. 155** (includes **Lady Dorothy, G.M.L. 103**).—This 21-acre lease, which includes the G.M.L. 103 (known as **Lady Dorothy**), was applied for in January 1895, and a considerable amount of work had evidently been done upon it. The old 6-acre lease the **Lady Dorothy** was applied for by Messrs. Dunsford and Church in 1894, and was eventually merged into the present one.

A tunnel 79 feet in length has been driven on a bearing of 60 degrees east for a distance of 79 feet to the foot of an adit shaft, 26 feet in length, which connects with a vertical shaft 10 feet in depth, Fig. 54. The section in the tunnel comprises a bed of conglomerate and grit, which is overlaid by a bed of fine sandstone, which occupies about 20 feet of the tunnel, starting from the centre of the drive at the face. From the face of the tunnel, a drive has been put in along the conglomerate for a distance of 136 feet. At the face of the drive, the old floor of the

<sup>1</sup> Geol. Surv. Bulletin, 20. Perth: By Authority, 1906, pp. 38 and 39.

underlying crystalline rocks has risen to the roof of the drive exposes barely an inch of fine conglomerate or grit. The maximum thickness of the basal auriferous conglomerate in the drive is 56 inches. Twenty feet from the mouth of the tunnel in this drive a winze has been sunk for a distance of 48 feet on the conglomerate

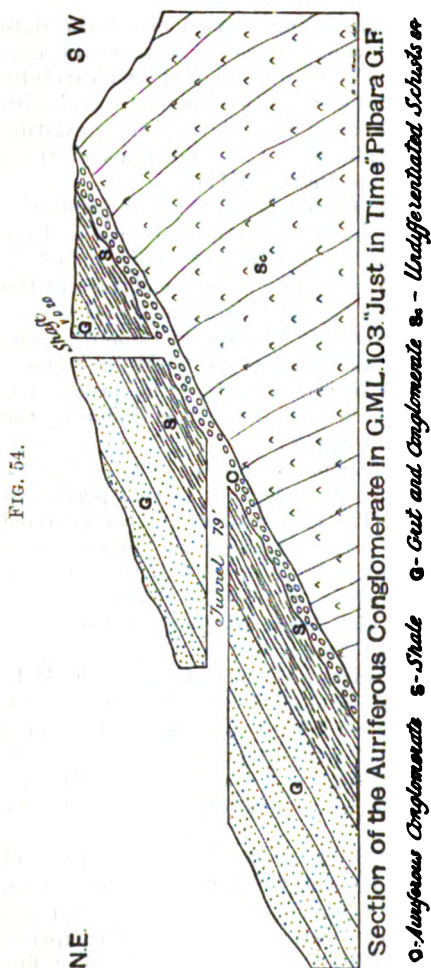


FIG. 54.

A main water shaft had been carried down to a depth of 100 feet, and judging by the material lying in the dump, bed rock must have been reached. This well, which is stated to have cost £1,000, yielded good water, but not in sufficient quantity for battery purposes. There are unfortunately no data available which indicate

which dips at an angle from 20 to 25 degrees from the bottom of the winze about 5 feet of a bouldery conglomerate, many of the boulders being from 12 to 18 inches in diameter. The drive has been put down north-west from the mouth of the tunnel, but has proved to be absolutely inaccessible. Between the drive at this level and the surface, there is an intermediate one of considerable length, but it proved to be inaccessible, unless some considerable personal risk.

At a point (1) on the map an attempt has been made to open out the conglomerate, the base of which is a somewhat higher level than that at the mouth of the shaft. The section was prospecting operations have been commenced showing the following: Conglomerate, 20 feet; shale, 5 feet 2 inches; ferruginous conglomerate [6496], 2 feet 4 inches; the whole resting upon older crystalline rocks. A sample of this on analysis in the official laboratory proved to be appreciably auriferous.

depth at which the base of the sedimentary series was met in the water shaft.

**JUST-IN-TIME EXTENDED, G.M.L. 164.**—This 20-acre lease was held for by Mr. J. A. S. Roe in 1895; this area comprised the alluvial ground, upon which a good deal of work has been done, which it was at one time intended to sluice. The lease, however, became void in December 1897.

A fair amount of prospecting work has been done at different points on the face of the escarpment of the conglomerate, which is all round the face of the hill.

At a point (2) on the map the conglomerate, which was 4 feet thick, was worked from the surface to the vertical shaft, which is stated to have cut the bed at 35 feet from the surface. From the top of the vertical shaft, the conglomerate is stated to have been traced down on the dip for a distance of 40 feet, and a good deal of material was stoped out. These workings, however, were inaccessible. The conglomerate is overlaid by a fine-grained and drabbed sandstone or sandy shale, which was also intersected in the vertical shaft.

### GENERAL

The following table shows the yield of the auriferous conglomerate, so far as such can be obtained from the returns of workings furnished to the Government:—

*Table showing the Yield of Auriferous Conglomerate from the Just-in-Time G.Ms., Ltd., G.M.Ls. 155, 164/5.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Prior to 1897 . . . .	30·00	45·00	1·50
1897 . . . . .	25·00	1·40	·05
1898 . . . . .	5·00	·90	·18
<b>Total . . . .</b>	<b>60·00</b>	<b>47·30</b>	<b>·78</b>

There is unfortunately no separate record of the gold which has been obtained from the "alluvial ground" on the face of the escarpment.

The occurrence of an auriferous conglomerate, in the same geological series, at least 50 miles distant from Nullagine, where identical geological conditions prevail, would seem to encourage efforts in the direction of carefully prospecting other members of the basal members of the series, which occupy such an extensive area in the north-west district.



## Q.—The Wodgina Tinfield

*(With a Geological Sketch Map, Plate XIX.)*

The Wodgina Tinfield is situated on the headwaters western branch of the Turner River, and within the limits Pilbara Goldfield as defined by the authorities, about 74 miles Port Hedland, and 15 miles due east of the Yule River, marks the boundary between the Pilbara and West Pilbara fields.

Tin appears to have been first officially recorded from this by the Warden during the year 1902. Since that date still has been given to prospecting in the vicinity, and during considerable activity manifested itself at Wodgina in the form of mining leases which had been pegged out. An important discovery of tantalum at Wodgina resulted in a considerable increase in population, but the excitement which this find made rapidly subsided with the heavy fall in the market value of the metal.

In addition to the discoveries at Wodgina proper, three others have been worked at what is known as the Stannum, about 9 miles to the south, upon the same range. This little group according to the official figures, produced 6·20 tons of tin during the short period which has elapsed since its discovery.

The total output from the whole of the Wodgina district according to the figures available up to the close of the year 1902 has been 31·45 tons of tin valued at £2462, and of tantalite 70·9 tons of the estimated value of £8925. There are good reasons for the belief that the tin yield disclosed by these figures does not represent the total yield of Wodgina, for tin buyers apparently have not commenced reporting their purchases towards the close of 1902.

## GENERAL GEOLOGICAL FEATURES

Geologically the district consists of a series of metamorphic sedimentary, and igneous rocks, the age of which has not yet been determined. These rocks skirt a very extensive granite mass which, as may be seen by an inspection of the geological sketch map (frontispiece), occupies a very large area of country.

These bedded rocks are very much folded and faulted and upon the whole have a prevailing dip to the west; they occur upon a very rugged range, which rises to considerable altitudes above the level of the surrounding plains. These rocks are pierced by granite and pegmatite veins (offshoots from the mass previously described) which invariably occur in intimate connection with the tin and tantalum ores. The occurrence of these pegmatite veins is of considerable economic importance, because all the known local deposits occur in association with them. These veins have been mapped in some detail both at Wodgina and Stannum. Geological maps of these two centres should afford a valuable guide to those engaged in mining operations on the field.



AL SKETCH MA

OF  
TINT

BARA G. F.

BY

W. B. TALBOT  
and  
J. B. MANTON

GEOLOGICAL SURVEY OF CANADA

W. B. TALBOT

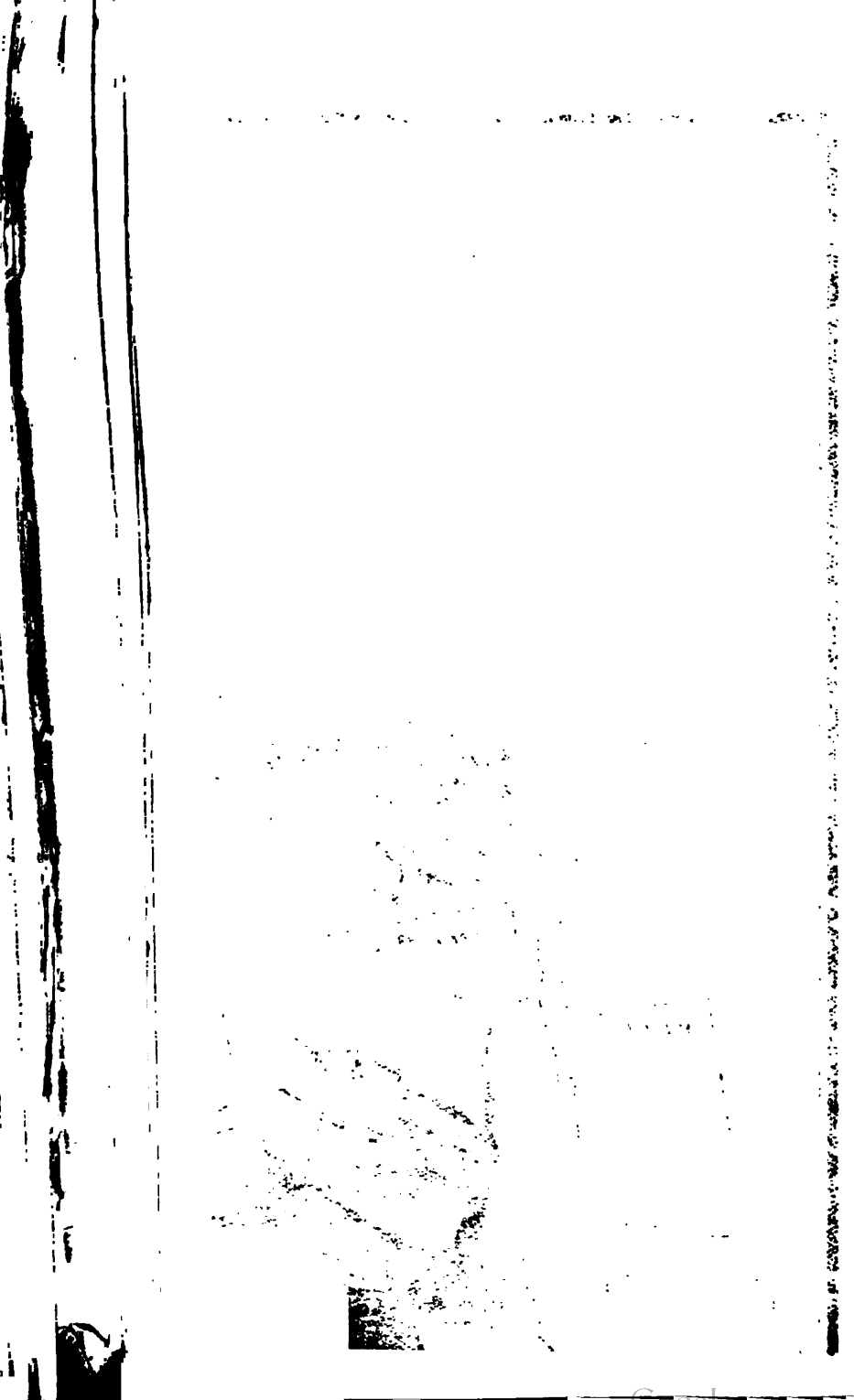
FIELD ASSISTANT

1902

SCALE OF CHAINS

ON OF COLOURS & SIGNS







Whatever may be the geological age of the main mass of the granite exposed at Wodgina, the intrusive granite is of decidedly later date than the folding, &c., which the bedded rocks have undergone, for neither the granite nor its offshoots have suffered any metamorphic alteration since their injection.

As far as has at present been observed, what may be called the belt of Wodgina is limited to the area occupied by the granitic dykes. Though, of course, the mode of occurrence of the tin at Wodgina<sup>1</sup> and Cooglegong in the heart of the granite some miles from its edge points to the fact that the tin at Wodgina need not necessarily be confined to the relatively narrow strip which comprises the apophyses of the granite mass.

The granite region of this portion of the Pilbara Goldfield comprises an area of, as may be seen by an inspection of the geological map which forms the frontispiece to this report, at least 100 square miles. The Wodgina belt proper extends, so far as observations have at present been carried, for a distance of at least 30 miles north-west and south-east, and has a width of about 30 miles.

The granite is composed of quartz, felspar, and mica, which is chiefly muscovite. The exact age of the granite cannot be determined; it passes under the Nullagine beds, which are assumed to be of Cambrian Age, hence, such being the case, the granite must be at least pre-Cambrian.

When laid down upon a map and viewed broadly, it is noticed that these veins have a rude parallelism, generally north-east and south-west, which is coincident with that of the dominant structural features of the district. The exception is in the case of those dykes which traverse the greenstones; here, where the dykes have been mapped, their general strike is north and south. In those cases in which the dykes depart markedly from what may be called the normal strike of the schists, it may be that the veins have followed old pre-existing fracture lines.

These pegmatite veins are seen to be offshoots from the main granite mass which covers such a large area of country to the east; a small angular portion of this granite occupies the south-eastern corner of the area mapped, and from this mass veins are seen to radiate. An interpretation of the general relationships of these veins to the main granite mass is shown in the geological section at the foot of the map which forms Plate XIX.

The dykes are very irregular, both in width and underlie, and are more persistent in strike than others; they vary from threads to veins over 500 feet in width, whilst their underlie is without any prevailing angle nor direction.

These veins are made up of a coarse-grained rock composed of quartz, felspar, and occasionally tourmaline, and may be regarded as pegmatite, using the term in the sense in which it was

<sup>1</sup> Preliminary Report on the Geological Features and Mineral Resources of the Pilbara District: A. Gibb Maitland, Government Geologist. Geol. Surv., Bull. 15. Perth: By the Government Printer, 1904, pp. 102-109.

applied by Delesse for any coarse-grained granitic rock containing mica, quartz, felspar, and tourmaline.

In the vicinity of and along the margins of many of the pegmatite dykes are bands or bunches of tourmaline; in some of these tourmaline bands occur only on one side of the dykes, suggesting as it were a marginal zone either in the dyke or in the adjacent country rock. In others the pegmatite dykes consist almost entirely of quartz, and are crowded with tourmaline, sometimes to such an extent as to make up fully one-third of the rock [6450].

The tin ore appears to be an original constituent of the granite, it is, however, so far as observations have at present been concerned, concentrated along certain lines in these dykes, and does not appear to be generally disseminated in minute quantities throughout the pegmatite. The tin occurs in all shapes, from minute grains to pieces weighing as much as 50 or 60 pounds.

The bed of the ravines and the slopes on the hillsides are covered with detrital and residual tin and tantalite everywhere over the area occupied by the pegmatite veins; and in many cases the detrital and residual tin has been traced to the pegmatite veins.

These pegmatites vary very much in their characters, and occur in different portions of the same vein.

The pegmatite [6478] which forms the tin lode of the Stannum mine, M.L. 79, is a coarse-grained rock, which traverses the whole length of the property, and sends off three branches indicated on the geological sketch map of the Stannum Group, Plate I. The rock is made up of quartz, albite, an amethystine lithiophilite, blue semi-transparent tourmaline, together with clear colourless topaz, which latter exhibits well-defined cleavage.

The very coarse-grained pegmatite [6466] opened out in the Williams' (or Bull's) lode claim, consists of quartz, a coarsely crystallised grey felspar, orthoclase, together with about equal portions of a fine-grained white felspar, which proved on investigation to be albite. A partial analysis of the orthoclase in the laboratory showed it to contain 12·80 per cent. of potash and of soda ( $\text{Na}_2\text{O}$ ) 3·00 per cent.

The bluish-coloured pegmatite [6454] which forms the tin lode traversing the Tinstone mine, M.L. 89, is a medium-grained rock consisting principally of quartz, lepidolite, together with orthoclase. The rock owes its colour to the presence of the mica, lepidolite.

Apart from the granite, which occupies the south-western corner of that portion of Wodinga which has been geologically mapped, the country is occupied by a belt of schistose rocks of which may have affinities with those of igneous origin, together with a large development of grits, quartzites, &c. The dip at varying angles to the westward.

Above these lie a great thickness of laminated iron-quartzites [6460], together with some very siliceous quartzites containing scarcely any iron [6452]. Portions of the ferruginous quartzites



ry much puckered and contorted, and even in hand specimens exhibit faulting on a very minute scale. These beds, which associated with bands of a nondescript rock approaching very to very ferruginous and siliceous clay slates, have on litho-grounds been separately distinguished on the geological map of the field, Plate XIX. The relation which these highly-ferruginous beds bear to those of the lower western slopes of the is by no means clear, though there are very strong grounds belief that in some portions of the field the junction between o series is marked by a line of fault.

a point (A) on the map is a fairly conspicuous band of a rock, which looks like a dyke; this continues without inter- to the north angle of M.L. 88, where it has been faulted. me rock extends also for about 10 chains north-east from n account of its making such a conspicuous feature in this n of the field, it has been separately distinguished on the ical map.

e north-eastern portion of Wodgina is occupied by fine-d bedded greenstone [6453], which in some places is vesicular others occasionally agglomeratic. The pegmatite veins which the tantalite occur in this greenstone area.

e general relationship of these rocks to one another is shown section at the foot of the geological map, Plate XIX.

very short distance east of the Government Well No. 1, and tside the eastern boundary of the geological map, is about 15 feet of a conglomerate of subangular quartz, which rests y upon granite. The conglomerate is of much more recent than the sedimentary rocks of Wodgina. Fragments of this conglomerate strew the surface over a considerable area, g that the formation must have been more extensive than ent obtains. It is possible that this conglomerate is an of the Nullagine Series, which occurs in great force in other ns of the district.

#### THE ORE DEPOSITS.

e following are full particulars regarding any of the workings, various ore deposits, opened up at the date of my visit to d. For purposes of convenience, the deposits are described the names of the respective leases.

L. 88, NIELSON.—This property is the most southerly of all ses situated at Wodgina proper. It lies about a mile south- f the Government Well, sunk on the east side of the range of hich separates the two mining camps.

e tin lode on this ground was discovered by tracing the tin in the creek below up the side of the hill to the site of the t workings.

far the larger portion of the property is included within may be called the tableland, at a considerable elevation above neral level of the surrounding country. The ground is

occupied by quartzites, mica, and hornblende slates, in addition to the iron-bearing quartzites (?), which latter cover fully three-quarters of the surface.

The only workings on the ground are situated near the northern boundary, and high up on the eastern face of the range. Openings have been confined to a thin sigmoid-shaped pegmatite dyke which is traversed by two, apparently vertical, faults having a strike of north-east and south-west.

The westernmost working is an opencut, exposing a total thickness of 8 feet of rock, containing a band of quartz (pegmatite) 12 inches in thickness, associated with from 12 to 18 inches of a clayey rock, which in all probability represents the aluminous portion of the pegmatite. This rock (the lode) has been exposed against the iron-bearing quartzite (?) on the west. So far as can be seen in the present condition of the workings, the quartzite appears to underlie southwards at a very low angle.

The band upon which prospecting operations were being carried out can be followed round the face of the hill to the eastern workings, which are 142 feet distant. At one spot between the workings the quartz vein has increased in thickness to 10 feet, but diminishes rapidly to the east. In the eastern workings the clayey rock (pegmatite) is about 5 feet in thickness, and exposes coarse angular tin [6451]. A very good pocket of tin was said to have been obtained from these workings, and, from what was pointed out to me, it appears that the rich ore pockets are almost invariably to have occurred near those spots where the tin is intersected by the faults.

From the eastern workings the dyke (the "lode") can be followed for some distance round the hill in the direction of the point shown upon the plan, Plate XIX. The dyke is composed of a vein of quartz, which can be followed across country for a considerable distance to the north-east; this is of some importance in that it shows that prior to the formation of the tin-bearing reefs had not only been formed but faulted.

M.L. 89, TINSTONE, Hazelwood.—The ground embraced by the boundaries of this lease lies near to and adjoins the southern angle of the Cassiterite, M.L. 84.

The property lies in the heart of the main range, and is intersected by the two important tributaries of the Two-mile Creek, the waters of the northern branch, a steep-sided ravine having been worked in a more or less desultory fashion for the detrital tin it contains. The surface of the lease is occupied by the iron-bearing quartzites (?) which everywhere make up the staple formation of the range. These bedded rocks are intersected by six distinct pegmatite veins, the positions of which have been laid down with a considerable degree of accuracy upon the geological map. In three of these the underlie of the veins could be distinctly made out, and in two of them the amount accurately measured; these data have been indicated on the map.

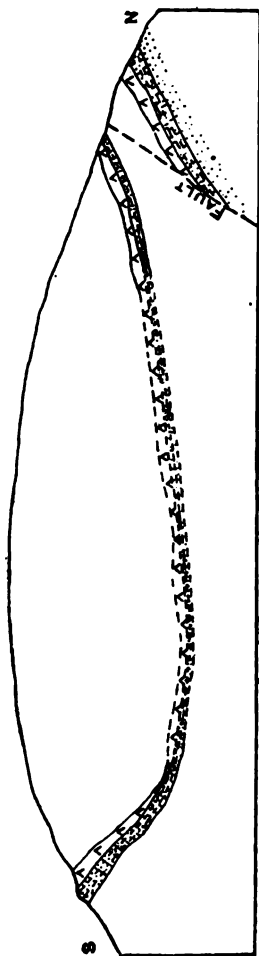


the north and south pegmatite vein which enters the lease on the eastern boundary of M.L. 85, the Commonwealth, is a [6454] of a cobalt blue colour, containing what appears to be crystals of felspar.

The most southerly working on the property is an open cut on the western extremity of the (boomerang) shaped site, which underlies at three to the northward. The open cut exposes a thin vein of maline rock [6454] under the surface at an angle of 40 degrees to the north, 40 degrees west, though at the south the vein dips at a steeper angle, 45 degrees, but in the same direction. The vein is of a dull leaden colour, and contains tourmaline and mica in much quantity, together with tin. It forms the foot of a decomposed pegmatite about 2 feet in thickness and rests directly upon the granite of the prevailing type. The vein can be followed round the base of the hill to a point directly above the mouth of the main tunnel.

The tunnel has been driven a distance of 64 feet in a direction of south 30 degrees west along the feather of a pegmatite dyke, near the mouth, is 2 feet in width and with a underlay to the east. The veins in the tunnel show the to be faulted, and in all probability it is separated from the one described by a fault, shown in the Fig. 55. Both of the dyke are highly tourmalineous and contain tourmaline; whilst the felspars of the pegmatite are very rapidly decomposing in the direction of kaolin. A little farther west is an open cut along the outcrop of the vein in the tunnel; it contains coarse angular tin and tourmaline. Fig. 55 shows the relation of the different veins to one another.

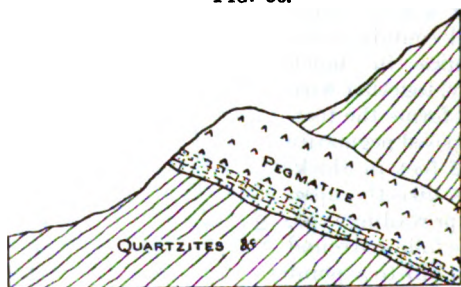
FIG. 55.

GENERALIZED SECTION ON THE TINSTONE LEASE M.L. 85  
WODGINA, PILBARA GOLDFIELD.

**M.L. 91, WODGINA STAR.**—This property adjoins the terite lease on its north-east corner, and on the eastern side the high ground which forms the main axis of the tinfield surface is drained by the upper portions of three creeks which flow into the tributaries of the Turner River. The northernmost of these creeks has been more or less extensively worked along its whole length. A large portion of the surface is occupied by pegmatitic veins, the position and extent of which are indicated upon the geological sketch map, Plate XIX.

The only work other than that in the creek done upon the ground is the sinking of a shallow prospecting shaft near the head of the northern creek, close to the boundary of the terite lease. This shaft had, at the date of my visit, been sunk down to a vertical depth of 20 feet, through the normal rock of the field, which in the shaft was found to be dip-

FIG. 56.

SECTION ON THE COMMONWEALTH LEASE M.L. 85  
WODGINA, PILBARA GOLDFIELD.

an angle of 60 degrees to the north-east. The shaft, as seen by an inspection of the map, is just upon the north side of a thin pegmatite vein, which extends from the adjoining lease to the west. The detrital tin in the gully below the shaft probably owes its origin to the disintegration of the dyke previously mentioned, and possibly in part to the one more immediately adjoining it on the north. No other work has been done upon the lease beyond that described.

**M.L. 85, COMMONWEALTH.**—This lease adjoins the Commonwealth lease on the south. The larger portion of the surface is occupied by the quartzites, and a small triangular patch of greenstone at the north-west angle of the lease. The quartzites, which are traversed by granitic and pegmatitic veins, the relative positions of which are indicated on the geological sketch map. The work done on this lease consists of an open cut 25 feet long in along the face of a pegmatite dyke, 6 feet thick, which lies at a low angle to the west. The under surface of the

5) contains a foot or two of a micaceous and tourmaline rock carrying tin of the ordinary type. Many large crystals of may be seen in the rock.

84, CASSITERITE.—This lease is the largest and earliest of the holdings at Wodgina. The ground was originally up by Messrs. A. G. McCarthy and David Ogilvie, in the year since which date it has, according to the official figures, produced 2.35 tons of tin.

The property occupies the highest portion of the range, which forms the backbone of Wodgina, and is drained by the tributaries of McCarthy's Creek, from one of which, Ogilvie's Gully, a considerable quantity of detrital tin has been obtained. Considerably more than two-thirds of the surface of the Cassiterite is occupied by quartzites and ferruginous clay slates of the type common to the district. The south-western portion of the lease is occupied by greenstones, which make up the whole of the country to the

An important feature in the geology of the property is the number and extent of the pegmatite veins which intersect the country rock in all directions and cover a fairly extensive area of the surface. The section which accompanies the geological map shows the relation which these dykes bear to one another.

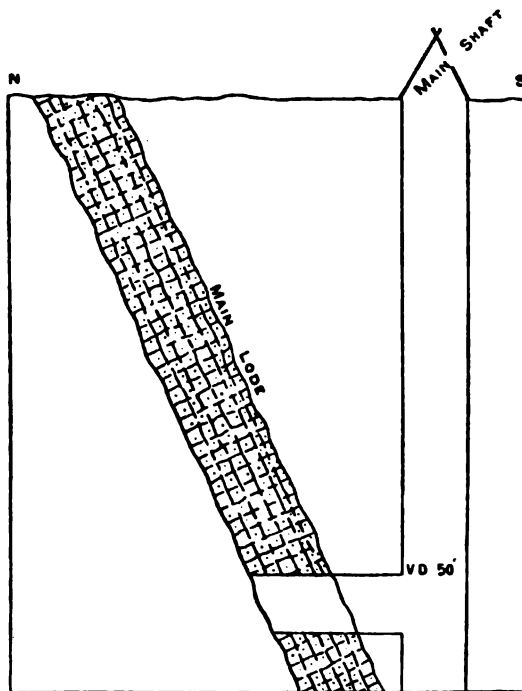
Not very much work has been done upon the lease considering the time it has been in existence.

Operations have up to the present been principally confined to the main lode, which is situated on the northern portion of the ground near the north-west angle of the

The main lode extends for some distance across the surface in the north-east and south-west direction. It outcrops north-east from the northern boundary of the lease for a distance of about 100 feet, at which point it ceases to make any appearance on the surface. Just outside the northern boundary of the lease, and just outside it, is an accessible vertical shaft (1) sunk to a depth of 20 feet, apparently to the main lode; at the mouth of the shaft is a quartz reef (tourmaline) 18 inches in thickness. The main lode, which carries coarse angular tin [6463], can be followed from the creek across the northern boundary of the lease up the side of the range in the direction of the main shaft. At 80 feet up from the creek the lode has been opened up to a depth of 11 feet; at the top it is 4 inches in width, but has increased to 2 feet 8 inches at the bottom. Very coarse angular tin occurs in the lode along the outcrop. One hundred and twenty feet farther to the south is the main shaft. At the date the property was visited, the shaft had been carried down to a vertical depth of 50 feet, at a distance of about 30 feet south from the outcrop of the lode. At the top of the shaft, which had been carried down through country rock, a crosscut had been put in to the north for a distance of about 100 feet at which point the lode was met with (Fig. 57).

The lode, which proved to be very micaceous, had been and showed slickensided faces. Coarse grey angular showing on both walls of the lode, which was about 8 thick. No other work than this appeared to have been the lode. From what was to be seen along the outcrop crosscut at 50 feet below the surface, the impression left

FIG. 57.



SECTION AT THE MAIN SHAFT, CASSITERITE LEASE  
M.L. 84 WODGINA, PILBARA GOLDFIELD

mind was that the lode occurred along a line of fault several occur in the district.

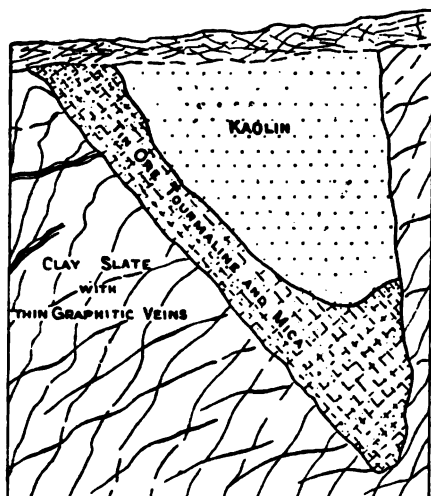
At a point about 500 feet southward from the main an open cut, 9 feet 6 inches wide, 10 feet deep and about in length, put in high up on the face of the range. The tion shows a wedge-shaped vein, 6 or 7 feet in height of which appears in Fig. 58.

The lode occurs in a somewhat ferruginous clayey quartzite, intersected by numerous graphite veins. contain relatively large quantities of a green mine



ite, a variety of chloropal. This green clayey-like mineral, examined in the laboratory, was found, at the hands of Mr.

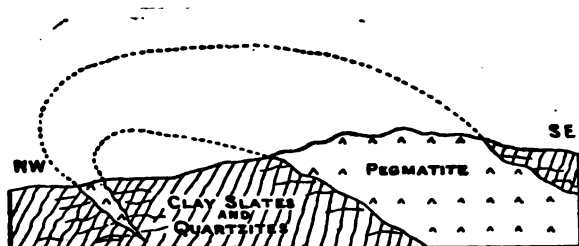
FIG. 58.



SECTION ON THE CASSITERITE LEASE M.L.84  
WODGINA, PILBARA GOLDFIELD.

son, to consist of  $\text{Fe}_2\text{O}_3$ ,  $\text{SiO}_2$  (32.2 %) and  $\text{H}_2\text{O}$  (20.1 %),  
her with traces of alumina and magnesia. The lode consists  
ipally of tourmaline and mica, together with tin ore, and is

FIG. 59.



SECTION SHOWING THE POSSIBLE RELATION OF THE VEIN IN FIG  
CASSITERITE LEASE M.L.84. WODGINA, PILBARA GOLDFIELD

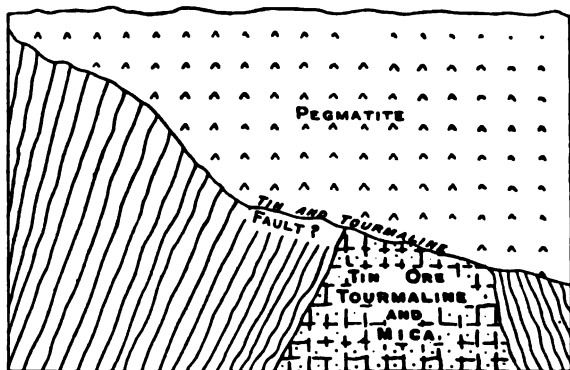
iated with kaolin, which in all probability represents the  
nposition product of a pegmatite vein.

What may be called the main pegmatite vein of the Cas-

siterite Lease lies at a point about 40 feet south from the vein, it is possible that the vein, exposed in the open cut, is a formed part thereof; the relationship of the two being shown in Fig. 59.

Another open cut, about 13 feet deep, has been put in at the base of the slope of the hill overlooking McCarthy's Creek, about 200 feet to the north-west of the main shaft. This open cut shows the following section:—

FIG. 60.



SECTION IN OPEN CUT ON CASSITERITE LEASE M.L. 84  
WODGINA, PILBARA GOLDFIELD

The pegmatite dyke which forms the upper portion of the open cut is about 7 feet thick, where exposed. It rests upon a rock of the usual type, the junction between the two being marked by a line of fault. The footwall of the vein contains a little tourmaline. In the deepest portion of the open cut there is an irregular mass of mica, tourmaline, and tin, about 4 feet thick on its upper surface. It had not, however, been followed to depth, so its behaviour underground could not be ascertained.

The only other work of any importance done upon the hill is that near the south-west angle, not far from the junction of the greenstones.

At this point, the position of which is indicated upon the geological sketch map, is a vertical shaft, No. 2, which has been carried down to a depth of about 22 feet. A granitic (or pegmatitic) rock was met with at 16 feet from the surface, and at the date of my visit it occupied the whole depth of the shaft. A second shaft had been put in at 16 feet for a distance of 15 or 16 feet in the general direction of north 45 degrees east. About 30 feet upward from the mouth of the shaft is the outcrop of one of the

c (or pegmatitic) veins, which traverses a considerable portion width of the lease. The relation of this vein to that entered in the main shaft is not by any means clear (Fig. 61).

An open cut, 25 feet west from the shaft shows, as has been noted in the figure, several similar thin veins, which in all probability mark the terminal points of offshoots from the main mass of dykes. The open cut is 63 feet in length; about 14 feet from the northern end of it is a thin vein, separated by about 16 feet from another, which measures about 12 inches in thickness, but gradually thins out to the surface of the ground. A somewhat larger vein of about 24 inches makes its appearance at a distance of 16 feet south from the last mentioned. There seem very good geological reasons for the belief that this vein connects with that met with in No. 2 shaft. Fairly coarse angular tin has been obtained at several places in the open cut, and in all probability it is of its origin to one or other of the veins exposed therein.

A fair quantity of stream tin has been obtained by dryblowing a portion of Ogilvie's Gully which traverses the lease. One specimen [6271] from this gully presented by the owners, and now in the Museum of the Geological Survey, weighs 43 lbs.; whilst another fragment (about one-half) of a large crystal [6272] from the same lease, and now on exhibition in the Geological Museum, weighs 28 lbs.

The following table shows the production of tin from this lease and as can be obtained from official sources:—

*Table of the Tin Yield of the Cassiterite Lease, M.L. 84.*

Year.	Tin Ore Raised.	Value thereof.
	Tons.	£
1904 . . . . .	6.35	497
1905 . . . . .	7.50	635
Total . . . . .	13.85	1,132

L. 110, Messrs. GUMMOW, MAY, AND DAWSON.—A lease, which has been applied for, adjoining the north-west corner of M.L. 84, overlooking the West Wodgina townsite, has been the subject of a little prospecting.

A vertical shaft (inaccessible to me) had been put down to a depth of 22 feet through quartzite; the shaft lies some little distance to the west of the small creek flowing northwards, which has been more or less extensively worked for the detrital tin it contains. A few feet west of the shaft a micaceous pegmatite vein has been opened up in one or two places, but no work of any importance has been done upon it. Coarse angular tin was showing in the micaceous rock lying near the mouth of the shaft.



A bold quartz reef outcrops on the north side of the creek and the east of the shaft previously alluded to.

M.L. 94, HAZLEWOOD.—On the ground pegged out as a adjoining the northern boundary of M.Ls. 91 and 84, a little

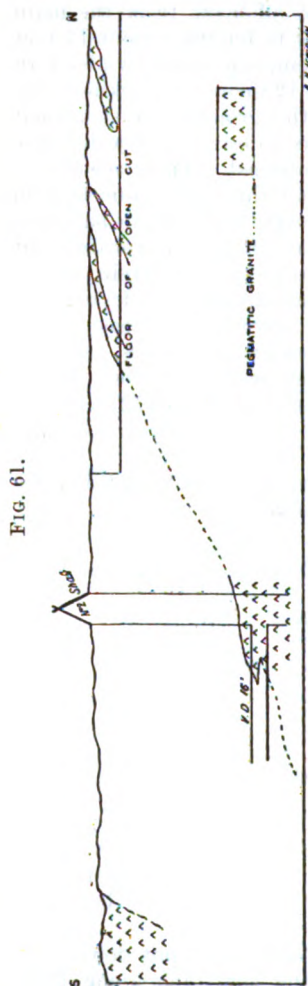


FIG. 61.

has been done upon a vein of pegmatite which outcrops near the summit of the hill, upon the northern slopes of which the tributaries of McCarthy Creek take their rise. The water flows generally north-east and then into the main watercourse at a distance west of the tantalum mine. The upper portion of this stream, which flows in a constricted and bound channel, has been more or less extensively worked, but there appears to be no record of the actual quantity of detrital tin obtained from it.

At a point (X) upon the ground, a tunnel 47 feet in length has been driven into the face of the hill upon a well-defined lode of tin ore lying at a high angle to the surface. The footwall of the lode is a zone of fault, marked by numerous slickensided faces, which run to the north. The lode is micaceous and in places contains the highly micaceous pyrite [6465] contain tin of the cassiterite type. The exact thickness of the lode does not appear to have been ascertained; it is at least 10 feet thick. The lode can be followed south-westward to the boundary of the Cassiterite Lease, but where there appears to be no more of it; it is possible, however, that the vein may be coterminous with one of those which form the system of the Cassiterite Lease.

The tin obtained from the

was in all probability derived from the disintegration of the tin ore. M.L. 117, MCCARTHY (FORMERLY J. C. WILLIAMS' OR CLAIM).—A claim, held by J. C. Williams, has been worked on the north-western boundary of the Cassiterite Lease; the position of the claim, owing to the ground not having been surveyed,

icated upon the geological sketch map, Plate XIX., of the  
 Its position may be approximately located by the shaft upon  
 which is situated at a point on the western boundary of the  
 Cassiterite Lease, distant about 500 feet from its north-west angle.  
 The shaft cut, 45 feet in length, has been put in along the northern  
 wall of the dyke, which is about 40 or 50 feet wide. The dyke,  
 consists of a rock [6467] made up of quartz, a coarsely  
 crystallised, grey, felspar orthoclase, together with about equal  
 proportions of a fine-grained white felspar, which proved, on  
 examination, to be albite. Good, coarse, angular tin occurs along  
 the wall of the dyke, and was showing in the dyke itself. It is  
 upon authority, which may be considered reliable, that about  
 10 tons of tin ore had been raised from this spot alone. A  
 shaft was being sunk on the southern wall of the dyke, and at the  
 time of my visit it had been carried down to a depth of about 8  
 feet, and very good prospects of tin were obtained from the surface,  
 at its mouth. So far as could be judged from what was available  
 in the section, the northern wall of the dyke appeared to dip to  
 the north at an angle of about 50 degrees, whilst the southern wall  
 appeared to be going down almost vertically. This vein is one of  
 the Cassiterite dykes which passes into the Cassiterite Lease, and adjoins the main  
 dyke on the top of the hill.

GENERAL.—Several other claims have been worked on the field  
 for residual tin, but they merit no special description.  
 In addition to the leases, &c., described above, by far the  
 greater portion of the tin so far obtained from Wodgina and  
 the Cassiterite Lease has been derived from the stream and residual deposits.  
 The quantity derived from this source is shown in a tabular  
 form below :—

*Table of the Tin Yield of Sundry Claims of Wodgina.*

Year.	Tin Ore Raised.	Value thereof.
1905 . . . . .	Tons. 12·50	£ 1030
Total . . . . .	12·50	1030

## THE STANNUM GROUP

(With a Geological Sketch Map, Plate XX.)

The group of three tin leases is situated about 8 miles south-  
 west from Wodgina proper, in the heart of the range which extends  
 to the latter locality. Upon these leases are several tin-bearing  
 Cassiterite dykes, which have been more or less exploited, and  
 the official figures have produced, up to the end of  
 1905, 5·20 tons of tin of an estimated value of £365.

A geological survey of the more immediate vicinities was made, and the results of which are shown on the map. The leases on this map are shown in their relative positions. In its general geological features the country differs in many particulars from the main mining centre of Wodgina. It occupies both sides of the main range, and sends out large areas of schists, &c., granitic and pegmatitic veins which even form the matrix of the tin ore.

In the vicinity of the Stannum, and occupying a large portion of the lease, M.L. 77, is a very large area of intrusive porphyry [6475, 6476, 6480] which is of later date than the granite which it pierces, and older than the granite and pegmatite. The mutual relationship of the two series is shown on the map of the group, Plate XX.

From the main mass of the porphyry, which occupies the Stannum Lease, M.L. 77, and forms the junction of the granite and the iron-bearing quartzites, three dykes emanate, as indicated on the map. There are, however, several other dykes which lie outside the area mapped.

This older porphyry varies very much in its general characteristics in different portions of its mass. One variety is a somewhat fine-grained, flinty-looking rock, which under the microscope, is seen to consist of plagioclastic felspar, with a characteristic turbid mealy aspect, a little dichroic, and a fine quartzose mosaic.

M.L. 77, STANNUM.—The Stannum Lease, which has been the scene of the first discovery of tin in the district, is drained by two important creeks, the positions of which is shown upon the geological map, Plate XX. The lease is made up of apparently bedded greenstone, intersected by a mass of porphyry, which has been subjected to the same set of stresses and strains as affected the greenstone which it pierces. These rocks are intersected by a very persistent dyke of pegmatitic granite which runs the whole length of the lease, after crossing the southern boundary of the property it extends southwards for about 500 feet beyond the limits of the area mapped. So far as this dyke is but thin, has been traced, it has a length of at least 1000 feet.

Near the centre of the property two branches of the dyke extend for short distances to the east. The northern branch has been followed down on the dip for a distance of 100 feet, at an angle of 35 degrees; the dyke averages about 12 inches in thickness. This vein sweeps round the face of the hill for about 15 feet from the main shaft, in which it is still to be met with at about 18 feet from the surface. The vein, however, was inaccessible at the date of my visit.


The southernmost branch vein has been opened for about 5 feet along the dip, which at this point is about 25 degrees to the south; the vein is about 12 inches in thickness and



PLATE 20



Sketch of  
Pilbara  
Museum  
by  
Maitland  
Geologist  
S. Talbot  
Assistant  
1905  
20  
OF CHAINS  
COLOURS &  
(in places)



THE HON  
MINISTERS  
GEOLOGICAL

STAN

AND GINA.

G. GIBB  
GOVERNMENT

H. W.  
BOUNDARY

is Number of

SCALE

EXPLANATION OF

SITE VEIN

ces. At a point on the main vein, distant about 200 feet west of the vertical shaft, it has been opened out for about 10 feet down dip, which is about 15 degrees in a direction south 15 degrees west.

The vein is 12 inches in thickness, and carries very coarse black sand and tin. Some desultory prospecting has been done at different points along the outcrop of the vein on the property, and judging from what can at present be seen on the surface, a little tin must have been found.

A little distance to the north of the main shaft is an extensive alluvial flat which traverses the northern portion of the lease, and has a maximum width of about 200 feet.

Upon that portion of the alluvium which lies directly north of the main shaft a fair amount of surfacing has been done and the topsoil stripped to three or four feet. A fairly large quantity of clean subangular tin has been obtained therefrom. This tin is due to its origin to the disintegration of the granite veins in its vicinity. The quantity of tin from this source is probably represented by the yield of this property for 1905, shown in the table below, viz., three-quarters of a ton.

The following figures give, in a tabular form, the total tin yield of the Stannum Lease, so far as can be obtained from the official records:—

*Table of the Tin Yield of the Stannum Lease, M.L. 77.*

Year.	Tin Ore Raised.	Value thereof.
	Tons.	£
1902 . . . . .	1·00	56
1903 . . . . .	·75	45
1904 . . . . .	2·60	139
1905 . . . . .	·75	60
Total . . . . .	5·00	300

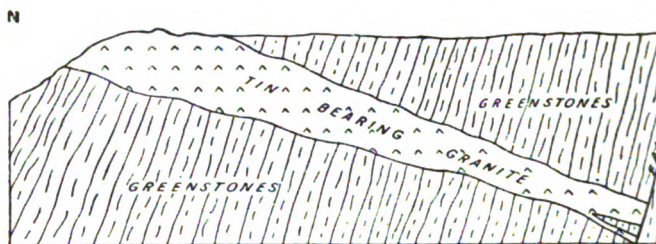
M.L. 79, STANNUM NORTH.—This lease lies on the lower slopes of the main range in the greenstone country, at the foot of the mass of quartzite, which occupies a large area of country in the vicinity. The lease is traversed by two tin-bearing granite veins [6477], which dip to the south at an angle of about 16 degrees. One of these veins has been opened out in three places. The most extensive of the two veins, "the lode," follows the contour of the hill as indicated on the map, Plate XX., and outcrops in the creek below at a point about 200 feet from the easternmost workings. It has been opened out in three places, the most westerly being a tunnel 32 feet in length driven along the vein, and dipping south at an angle of about 16 degrees. The vein is about 4 feet in thickness at the north of the tunnel, but gradually diminishes down the hill. At the face of the tunnel the vein is about 12 inches in thickness.



The section which forms Fig. 62 shows this vein.

M.L. 80, COMET.—The Comet Lease lies on a totally different watershed to that which includes the Stannum group. The g is situated on the southern slopes of a very high precipitous which rises to a considerable altitude above the level of the below. The lower portion of the leases is occupied by a greenstone of the type prevailing in the district, which is traversed by several faults, the position of which is indicated on the geological map. The iron-bearing quartzites occupy the higher portions of the country, and make a very prominent feature in the district. As may be seen by an inspection of the geological plan of the Plate XX., the central portion of it near the junction of the formations is traversed by a small micaceous granitic vein [which carries a little tin. The vein has been opened out by a tunnel driven 50 feet into the face of the hill on a bearing of 45 degrees east at a considerable elevation above the level

FIG. 62.



creek. The tunnel has been carried along the vein, which from 2 to 3 feet in thickness. At 25 feet, however, from the mouth of the tunnel its place is taken by vertical beds of quartzite identical with those forming the higher ground on the northern portion of the lease. It is possible that the point at which the vein disappears in the tunnel is a fault, of which there are several in the vicinity. Further round the face of the hill to the north the same vein has been opened up on the outcrop by a very small prospecting shaft, which, however, was inaccessible. A little tin was to be seen in the granite veins forming the dump at the mouth of the shaft.

#### CONCLUSION.

Although the general result of such operations as have been carried out up to the present time indicate clearly that the existence of lode tin in sufficient quantities to be profitably mined has not been demonstrated, owing to the fact that work has hardly gone beyond the most rudimentary prospecting stages, there



grounds for the belief that the district bids fair to rise to  
 nance, and that it will continue to be both a tin and a  
 e producer. As the tin in the deposits of the nature of  
 occurring at Wodgina apparently owes its origin to a  
 ion during the cooling of molten igneous rocks, it is likely  
 ist to considerable depths provided the continuity of the  
 s is not interfered with by faults of later date.

development of tin lodes, however, is a much more lengthy  
 than the exploitation of residual and stream tin deposits,  
 course cannot be carried out without capital judiciously  
 ed in providing the necessary equipment and in exploration

scarcity of fuel and water, however, is an important factor  
 should the deposits on further exploration prove of com-  
 importance, unless successfully overcome, will act as a  
 nt to profitable mining.

*Synoptical Table of the Tin Yield of Wodgina  
 and Stannum.*

Name of District.	Tin Ore Raised.	Value thereof.
	Tons.	£
Wodgina . . . .	12·35	1,007
Stannum . . . .	5·00	300
Sundry Claims . . . .	12·50	1,030
Total . . . .	31·45	2 462

ere seem very good reasons for believing that the tin yield  
 ed by these figures is considerably under the truth, for the  
 yers apparently only commenced reporting their purchases  
 Government towards the close of 1905.

#### THE TANTALITE LODS. (WODGINA. Plate XIX.)

L. 86, H.M., and M.L. 87, ANCHORITE.—A very important  
 of the Wodgina Field is what is known as the Tantalite  
 ne position of which is shown on the geological sketch map  
 field. The "lode" traverses the whole length of two of the  
 applied for, viz., H.M., M.L. 86, and Anchorite, M.L. 87.  
 the most southerly of the two not very much work has been  
 operations having been confined to dryblowing the surface  
 the outcrop and in the vicinity of the pegmatite vein.  
 e pegmatite vein (the "lode") first makes its appearance  
 e boundary of the Anchorite ground, to the south of  
 thy's Creek, and after traversing the whole extent of the  
 properties, extends northwards far beyond the limits of the  
 ical map. The vein had been opened up in the H.M. ground,

M.L. 86, for a length of 45 feet, but only to a depth of 4 feet. To the north of the open cut its width is 41 feet, 204 feet farther it has dwindled to 34 feet, whilst near the north boundary a commencement had been made with the sinking of a shaft in the open cut on M.L. 86.

As the operations had not been carried on sufficiently far to enable either the thickness of the vein or the amount of its underlie being obtained; as the work proceeds, however, definite information upon these material points should be available.

The section, Fig. 63, which has been drawn to scale, indicates the relation of the tantalite lode to the surrounding rocks.

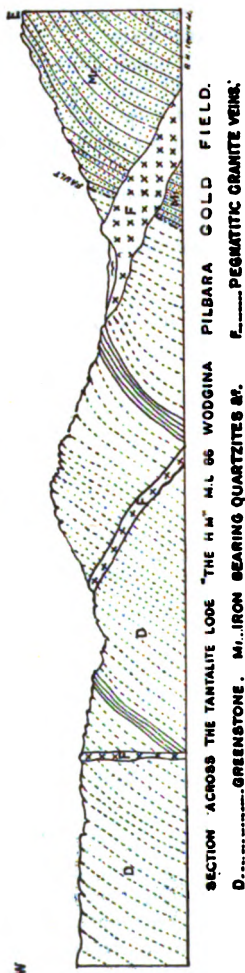
A considerable amount of detrital tantalite was being carried out up the slope of the hill adjoining and to the west of the lode over the areas shown by stippling on the geological map. Several tons of tantalite, some of which being very coarse (pieces as much as 37 lbs. being not uncommon), have been obtained in this manner, and it is estimated that about 71 tons of the material have been taken from the surface of the leases. This detrital tantalite is derived from the disintegration of the shoot occurring in the vein adjoining the lode.

The dyke, which traverses the greenstones which make such a conspicuous feature in the geology of the portion of the Wodgina Field, varying in its character in different portions along its outcrop, is in some places much the same throughout. It consists essentially of quartz, felspar, and mica; in addition to which it contains tantalite in pieces of all sizes, the largest of which weighed 5 hundredweights.

Some portions of the dyke, however, consist almost entirely of felspar [6458]; at others, quartz and minute scales of lithia mica [6457]; whilst in other places it is represented by pure quartz. In some places there seems to be a gradual passage from an ordinary pegmatitic granite to pure granite.

About 300 feet west of the main tantalite lode is another dyke containing tantalite; dryblowers have been used to

Fig. 63.



the southern end of it, and had obtained about one hundred-  
t of somewhat fine-grained ore.

What may be called the tantalite group of lodes has been  
ed with more or less interruption for about a mile to the  
of M.L. 86, and eventually merges into the granite mass of  
ains. A fair quantity of detrital tantalite has been obtained  
this locality, and there is every reason to believe that the area  
which the mineral occurs will be extended.

According to the returns taken from the *Government Gazette*,  
eld of tantalite has been, up to the close of 1905, as shown in  
ble below :—

*Table of the Tantalite Yield of Wodgina.*

Name of Lease, &c.	Ore Raised.	Estimated Value.
	Tons.	£
H.M. and Anchorite, M.Ls. 86, 87	26.00	3,425
Naismith's Unreg. Claim . . .	45.60	5,500
Total . . .	71.60	8,925

**EADIE'S CLAIM.**—On a bearing of 358 degrees, and distant  
78 chains from M.L. 86, is what is known as Eadie's Claim,  
which is a pegmatite dyke of the prevailing type and contain-  
little tantalite. The dyke measures about 20 feet in width on  
surface, and occurs in greenstone country identical with, and  
ntinuation of, that occurring in McCarthy's Creek.

The only work done, however, consisted in opening up the dyke  
depth of about 3 feet. This deposit is virtually the con-  
tion of the main tantalite lode previously described, which  
s followed more or less continuously to this point, near which  
ppears into the low country of the plains.

One hundred feet distant, on a bearing of 305 degrees, is a  
wn patch occurring on a pegmatite dyke of the ordinary type.  
r quantity of detrital tantalite had been obtained from this  
y at the date of my visit.

**MOUNT YORK.**—A recent report from the Acting Inspector of  
(submitted to the Minister for Mines in January last) on the  
ence of tantalite at Mount York<sup>1</sup> (Chingamong), about 20  
east of Wodgina, in a mineral belt which trends generally  
and south, and parallel to that at Wodgina, describes the  
workings in the district :—

On M.L. 100 (O. T. Bell and party) a rubbly felspar forma-  
as been exposed for a few feet. This carries tantalite, but  
ent work has not been done to allow of an opinion as to the

position of Mount York is not shown on any of the official maps, and has probably  
fixed.



richness of the lode. On McBeth's alluvial reward claim for) tantalite can be easily seen in the gully that traverses the claim. . . . Several tin lodes have been pegged out in this but little if any work has been done on them."

The "felspar formation" which the Inspector describes is without doubt one of the pegmatitic dykes which occur in such force at Wodgina.

No opportunity presented itself of visiting this find, but on my way to Perth I was shown at Lalla Rookh, by Mr. Wm. . . . one of the owners of the find, a large quantity of dressed tantalite, a sample of which was assayed in the Survey Laboratory and yielded:—

Metallic tin . . . . .	15·62 per cent.
Tantalum pentoxide, $Ta_2O_5$ . . . . .	42·39 ..
Niobium pentoxide, $Nb_2O_5$ . . . . .	21·09 ..

In this sample much of the tantalite occurred in the form of defined crystals.

The occurrence of tantalum ores has been known in this State for a number of years, full particulars of which have been given in several of the Bulletins of the Survey.

Tantalum was recorded as occurring in this State at several places, viz., Stibiotantalite (tantarate of antimony) in 1891, 1900, Tantalite (tantarate of iron) was detected in the Survey Laboratory, in some of the alluvial wash from the Greenfield Tinfield; Manganotantalite (tantarate of manganese) in 1901, material sent in from Wodgina; and in 1905, Manganocobaltite (niobate and tantarate of manganese) and Calcipotantalite (tantarate of iron and lime) from Wodgina and Mount York (Chingam).

An analysis of a sample of manganotantalite [6459] from Wodgina, M.L. 86 has been made in the Survey Laboratory by Mr. Simpson:—

$Ta_2O_5$ . . . . .	68·65
$Nb_2O_5$ . . . . .	15·11
$TiO_2$ . . . . .	·40
$SnO_2$ . . . . .	·48
$WO_3$ . . . . .	Trace
$H_2O$ (combined) . . . . .	·07
$FeO$ . . . . .	1·63
$MnO$ . . . . .	14·15
$NiO$ . . . . .	Trace
$CaO$ . . . . .	Trace
$MgO$ . . . . .	·15
$(Ce.Y)_2O_3$ . . . . .	Nil
	<hr/> 100·64 <hr/>
Specific Gravity . . . . .	7·03

<sup>1</sup> J. J. East. On Stibiotantalite, a new mineral from the Stanniferous Gravel bushes, Bunbury, Western Australia. Trans. Aust. Inst. Mining Engineers, 1900, pp. 139-142.

the tantalite of Wodgina, as may be seen by a reference to the analyses, contains a fairly large percentage of the comparatively useless niobium oxide. The recently announced discovery<sup>1</sup> of a method for the separation of the tantalum and niobium oxide is of importance, as it may eventually add commercial value to those tantalite deposits which, owing to their high percentage of niobium, are at present practically useless.

Having due regard to the uses to which recent scientific research has shown the metal can be put, provided the tantalum-bearing minerals can be obtained in sufficient quantities, the find at Wodgina is of considerable importance, and should be the means of encouraging prospecting in other districts in which identical geological conditions prevail.

The following account of tantalum, its detection and uses, has been drawn up by the Mineralogist and Assayer, Mr. Simpson:—

## TANTALUM

### ITS DETECTION AND USES.

Tantalum, and its so far valueless twin brother Niobium, which always accompanies it in nature, were discovered as long ago as 1801. It was not, however, till the year 1904 that tantalum was prepared in a state of great purity and its intrinsic qualities determined. Tantalum is prepared by passing a strong current of electricity through a rod of the pure oxide in a carefully maintained vacuum, and also in an equally pure state by fusing tantalum fluoride with metallic potassium in an evacuated electric furnace.

As prepared, tantalum is a hard grey metal, considerably heavier than gold, but lighter than silver. It is very ductile, and can be drawn out into the finest wire. At the same time, when hammered it becomes harder than the hardest steel, and has therefore been suggested as a substitute for diamond in drilling. In a vacuum its melting point is found to be higher than that of platinum, but when heated in air it becomes oxidised—superficially only at a red heat, completely at a white heat. It is unaffected by all acids except hydrofluoric.

At present its use is confined to providing filaments for incandescent electric lamps. For this purpose it is found to be extremely well suited, having a long life and using only about half the usual amount of current for the same candle power. The demand for these lamps is already so large that the Messrs. Siemens & Halske, are unable, with an output of 5000 lamps a day, to satisfy the demand. One kilogramme (a little over two pounds weight) of tantalum is sufficient for the production of 45,000 lamps. Its alloys with iron are found to combine great hardness and durability with ease of working, and it is probable that they will be put to some use in the near future.

Coming now to the question of the natural supplies of the metal, it may be noted at the outset that tantalum does not occur in the metallic state in nature, but only in a few rare and complex compounds of the oxides of tantalum and niobium with the oxides of other metals. The most important of these are:—

*Tantalite* (tantalite and niobate of iron and manganese).—This is the most common and most important ore and comprises several varieties, dis-

<sup>1</sup> The Mining Journal, London, 28th October 1905.

tinguished by differences in crystalline form, and in the relative amount of tantalum, niobium, iron, and manganese present. They are as follows:

Tantalite, tantalum pentoxide . . . . .	43 to 85 per cent.
Manganotantalite, tantalum pentoxide . . . . .	43 to 85 "
Columbite, tantalum pentoxide . . . . .	1 to 42 "
Manganocolumbite, tantalum pentoxide . . . . .	1 to 42 "
Skogbolite, tantalum pentoxide . . . . .	43 to 85 "

Typical tantalite occurs at Greenbushes, manganotantalite at Pilbara G.F.). At this latter locality there also occurs a new variety characterised by the presence of a high proportion of lime (7·8 per cent). Specific gravity, 5·3 to 7·9. Colour, black; opaque.

*Microilite* (tantalum and niobate of calcium).—Tantalum pentoxide 48 per cent. Specific gravity, 5·3 to 6·1. Colour, yellow to brown; translucent.

*Stibiotalantite* (tantalum and niobate of antimony).—Tantalum pentoxide 51 per cent. Occurs at Greenbushes. Specific gravity, 6·4 to 7·4. Colour, grey, yellow, or brown; translucent or opaque.

*Ytrotantalite* (tantalum and niobate of yttrium, iron, &c.).—Tantalum pentoxide, 46 per cent. Specific gravity, 5·4 to 5·9. Colour, yellow to black; opaque.

*Fergusonite* (tantalum and niobate of yttrium, erbium, &c.).—Tantalum pentoxide, 2 to 43 per cent. Specific gravity, 4·7 to 5·8. Colour, black; opaque.

*Samaraskite* (tantalum and niobate of iron, uranium, &c.).—Tantalum pentoxide, 2 to 18 per cent. Specific gravity, 5·0 to 6·0. Colour, black; opaque.

Tantalum-bearing minerals are usually found in granitic country in pegmatite veins or bands in the rock mass, or in surface boulders and pebbles derived from them. Tin ore is sometimes associated with them, so that tin concentrates should be examined for their presence. It was in this way that they were first detected at Greenbushes.

There is no simple blowpipe or other test for the presence of tantalum. It is useful, however, to remember that minerals containing notable amounts of this metal are all extremely heavy. A considerable amount of work has been devoted by the author to the question of the detection of tantalum ores, and the following methods have been evolved:—

*Detection.*—The suspected mineral or black sand or tin concentrate is ground to an impalpable powder in an agate mortar, and half as much will go on a threepenny piece (say  $\frac{1}{2}$  gramme) is fused in a nickel crucible over a red heat with six times its weight of caustic potash. The crucible is then cooled and the melt dissolved out with hot water and put in a beaker containing a moderate excess of dilute hydrochloric acid, and boiled. If a creamy or opaque flocculent precipitate forms immediately, tantalum or niobium is present, and the material should be subjected to a complete separation as described below. Care must be taken not to confuse with the precipitate of titanium hydrate formed under somewhat similar circumstances. If sufficient acid is present the latter will not form at all, and only a slight excess of acid is present it will form *slowly* on warming, and becoming heavier. It is finely granular as compared with the precipitate.

The value of tantalum ores depends principally upon the percentage of tantalum pentoxide ( $Ta_2O_5$ ) in them, but is lessened in proportion to the percentage of niobium pentoxide ( $Nb_2O_5$ ) associated with it. Roughly speaking, it is worth in London £1 per unit, the market being very unsettled, the demand at present being very restricted. Quotations twelve months

<sup>1</sup> A rounded pebble (6286) weighing 18 grammes, and grey-black in colour, has been analysed and found to contain the following composition:— $Ta_2O_5$  73·82,  $Nb_2O_5$  6·44,  $SnO_2$  7·2,  $TiO_2$  8·42,  $MnO$  1·39,  $CaO$  7·78,  $MgO$  0·62,  $Ce_2O_3$  nil—total, 99·73.

1905) ranged from 3½d. per lb. for 5 per cent. ore up to 18s. per lb. for cent. ore.

The following determinations have been made on ores from this State:—

Tantalite, Greenbushes . . .	Ta <sub>2</sub> O <sub>5</sub>	80·61 %	Nb <sub>2</sub> O <sub>5</sub>	2·50 %
" " " " " " " " " "		68·50 "		5·46 "
Biotalite, Greenbushes . . .		51·13 "		7·56 "
" " " " " " " " " "		50·57 "		12·58 "
" " " " " " " " " "		51·95 "		4·49 "
Manganotantalite, Wodgina . .		69·95 "		14·47 "
" " " " " " " " " "		72·46 "		6·80 "
Biotalite, Wodgina . . .		73·82 "		6·44 "
Manganotantalite, Green's Well .		54·76 "		27·24 "
Tantalite, near Lalla Rookh . .		70·34 "		4·92 "

The above assays are mainly those of bulk samples. Individual fragments from the Wodgina Field are very variable in specific gravity, and therefore assay value. The observed range is from 5·50 (=10 per cent. Ta<sub>2</sub>O<sub>5</sub>) (=84 per cent. Nb<sub>2</sub>O<sub>5</sub>).

Samples of these ores are to be seen in the Geological Survey Office, Port Street.

**ay. 1. Simple rough Method for Buyers.**—A close relationship exists between the specific gravity of tantalite and its varieties and the very variable percentage of tantalum pentoxide contained in them. In buying, therefore, tantalite free from tin ore, &c., a rough assay (to be subsequently checked by a chemical method) may be made as follows:—The specific gravity of several of the fragments of mineral is taken carefully, and their specific gravity calculated, or the specific gravity of a representative portion of the finely crushed sample is taken, and the percentage of Ta<sub>2</sub>O<sub>5</sub> taken from the following table:—

Specific gravity	5·3	Ta <sub>2</sub> O <sub>5</sub>	Iron-tantalite.		Mangano-tantalite.	
			%	Trace		2
"	5·5	"	6	.	.	10
"	5·7	"	14	.	.	19
"	5·9	"	22	.	.	27
"	6·1	"	30	.	.	36
"	6·3	"	38	.	.	44
"	6·5	"	45	.	.	51
"	6·7	"	52	.	.	59
"	6·9	"	59	.	.	66
"	7·1	"	65	.	.	72
"	7·3	"	70	.	.	78
"	7·5	"	75	.	.	83
"	7·7	"	79	.	.	...
"	7·9	"	84	.	.	...

This is usually correct to within less than 5 per cent.

**Chemical Method.**—The method here described is not applicable to tantalite, as it does not effect a separation of Sb from Ta and Nb. It may be modified somewhat when the Ta<sub>2</sub>O<sub>5</sub> present is not greater than one-fifth of the Nb<sub>2</sub>O<sub>5</sub>.

**Composition.**—Crush ore through a 90 sieve and mix well. Put between 2 and four grammes of pure KHO in a 1½-inch nickel (or silver) crucible, and set over gauze to melt whilst ore is weighed out. Weigh out 0·5 gramme of ore, grinding it all very carefully in an agate mortar in lots of not more than 0·2 gramme before putting it on the weighed watch-glass. By the time weighing is completed the KHO will be in a state of tranquil fusion. Remove the burner and drop in the ore, mix well by quickly rotating, replace on cover and heat for 10 minutes. Remove lid and repeat rotation, then remove the crucible in a 1½-inch hole in a sheet of one-eighth inch asbestos so that the ore is not more than one-third of the crucible projects below. Cover and heat



over naked bunsen for half-hour so that bottom of crucible is bright. The melt is very liable to creep, but this is avoided by heating over a support as here described. At the end of half-hour fusion is complete and bunsen is removed. Remove cover carefully so as to avoid losing any liquid melt from its under surface. Set lid aside upside down to catch the melt solidifies on the side, which makes subsequent solution easier. While cooling, measure out 30 cc. 5E.HCl, and pour about 10 cc. into bottom of a beaker of not less than 400 cc. capacity. Wash the lid with this first with warm water, then with a little of the measured acid, then with a "policeman,"<sup>1</sup> and finally wash again with water. Cover crucible with a watch glass, and through a small gap on the side away from the melt the crucible two-thirds full with slightly warm water from a wash bottle. Action is somewhat violent for a few seconds. When it is tranquil, pour into the beaker, wash well with warm water, then with the remainder of the measured acid, rub well with policeman, and finally wash well with water.

*Determination of Ta<sub>2</sub>O<sub>5</sub> and Nb<sub>2</sub>O<sub>5</sub>.*—Add to the solution, which shows now measure more than 80 or 90 c.c., 5 to 10<sup>2</sup> c.c. of 10E HCl and place in sand bath to boil. (The original solution of the melt is usually green from presence of K<sub>2</sub>MnO<sub>4</sub>, on acidifying with acid the colour changes to red from the formation of KMnO<sub>4</sub>, MnO<sub>2</sub>, and hydrates of Ta and Nb being precipitated at the same time. On boiling both KMnO<sub>4</sub> and MnO<sub>2</sub> are attacked, forming MnCl<sub>2</sub>, and liberating Cl<sub>2</sub>, whilst Ta and Nb hydrates remain in solution except in traces. Boil the solution till all Cl<sub>2</sub> is driven off and the precipitate is no longer brown, but creamy white. Dilute to 200 c.c. and boil for further 15 minutes to ensure complete precipitation of the Nb. Filter through a 12 c.m. paper, pouring supernatant liquor through first without disturbing the precipitate, the filtration being thus hastened. The filtrate should be clear; if milky it probably contains Nb, which must be precipitated by further diluting and boiling. Wash precipitate on filter with boiling water until washings give no reaction with AgNO<sub>3</sub>. Residue consists of hydrates of Ta, Nb (and W?), with all Sb, and at times traces of Mn<sub>2</sub>O<sub>3</sub> and SnO<sub>2</sub>. The filtrate contains all Sn, Fe, Mn, Ca, Mg, Cu, Ni, and Ti as chlorides. The filter and residue are almost completely dried in a water oven, folded and put in a covered and weighed porcelain crucible, and heated up gradually in a gas muffle or otherwise. When nearly red remove lid and heat to redness, till all carbon is burnt off, then ignite a further 15 minutes. Cool in desiccator, and weigh as Ta<sub>2</sub>O<sub>5</sub> + Nb<sub>2</sub>O<sub>5</sub>.

*Separation of Ta<sub>2</sub>O<sub>5</sub> and Nb<sub>2</sub>O<sub>5</sub>.*—All Ta and Nb must first be converted into the form of hydrates, either by fusing a fresh portion of ore as before, or by treating the weighed oxides in the same way as an ore. In the latter case the fused KHO must be cooled until solid before addition of the acid, otherwise loss may occur.

It is convenient to use for the separation four platinum dishes, of 2", 2½", 3", 3½".

The well-washed hydrates are washed almost completely off the filter into a 3" platinum dish. The filter is then folded into four inside out and put in a second (3½") platinum dish, covered with hot water and a few drops of HF added, and the solution warmed on a sand bath for a few minutes. Pour off the solution into the dish containing the Ta and Nb, repeat the operation, and finally wash the filter at least four times by decantation with hot water. Set solution of Ta and Nb on sand bath to heat, and if precipitation of hydrates is not complete in a few minutes add one or two drops of HF, avoiding carefully any great excess. Weigh, roughly, 0.7 gram of KF (or more if moist), dissolve in hot water, and after heating the solutions nearly to boiling, add the KF slowly, with stirring, to the solution of Ta and Nb. Evaporate to 10 c.c. Wash down sides of basin with drops of hot water and set on one side to cool slowly down to 15° C.

<sup>1</sup> "Policeman"—a glass rod with a small cap of rubber tubing.

<sup>2</sup> The larger quantity is used when much Ti is present. 5 cc. is sufficient when little Ti or Mn are present.

thly cool, decant clear solution containing all Nb and part of Ta in a 7 cm. filter into a small ( $2\frac{1}{2}$ " ) platinum dish. Wash residual mass of spicular crystals of  $K_2TaF_7$  with four small lots of cold water, adding washings to main solution. Evaporate over water bath at 5 c.c., cool slowly as before. Decant or filter off solution through a (7 cm.) filter, supported on a well-waxed glass funnel, into a 2" dish. Add four small lots of cold ( $15^\circ$ ) water and examine residue for flat of  $K_2NbOF_6$ . If present, they must be removed by further washing. Evaporate solution to dryness at  $100^\circ$ , cool, add one drop HF and dissolve 0.1 g. KF in 1 c.c. of water. Then run into dish from a burette from 1 to 5 c.c. of (usually 3 c.c.) water according to proportion of Nb expected to be present, viz., about 1 c.c. for every 7 per cent.  $Nb_2O_5$ . Heat rapidly for a few seconds to dissolve all residue, add the solution of KF, and make note of total solution, and set on one side to cool for one hour at  $15^\circ$  C. or lower.<sup>1</sup> Filter solution into a small platinum dish and wash residue four times with a few drops of water at  $15^\circ$  or less, making a note of approximate bulk of the washings. Add to solution 8 c.c. 10% KOH and evaporate to fuming on a sand bath. Keep strongly fuming for 20 minutes in order to remove last traces of fluorine. See that no unacted fluorides remain on the side of dish out of reach of the sulphuric acid. Cool and pour into 150 c.c. water contained in a 300 or 400 c.c. beaker. Rinse dish well with chilled water and a policeman. Boil solution for 10 minutes to precipitate all Nb and Ta associated with it, filter, wash well with boiling water and dry. Ignite until all filter is burnt, cover, add 1.0 gm. ammonium carbonate, cover and reignite till constant in weight. Weigh residue which contains all the  $Nb_2O_5$  and part of the  $Ta_2O_5$ . The latter is determined for on the following basis, viz., .00365 gm.  $Ta_2O_5$  for every 1 c.c. of solution in which the final crystallisation took place, and .00091  $Ta_2O_5$  for every 1 c.c. of wash water used in the final filtration.

**Determination of Tin.**—Warm the main solution containing the chlorides of Fe, &c., and pass  $H_2S$  to saturation. Filter off the  $SnS$  and wash well with 2% water. Convert into  $SnO_2$  as usual, and weigh after ignition.

### B.—Cooglegong Tinfield

The Cooglegong Tinfield is situated on one of the tributaries of the Shaw River, a little to the west of the White Quartz Hill. It is upon the geological sketch map of the Pilbara Goldfield, and forms the frontispiece of this report. The field is claimed to have been discovered in August 1900, and since that date it has (up to 1906) returned 760.35 tons of tin ore, valued at £52,179.

### GENERAL GEOLOGICAL FEATURES.

As is the case at Moolyella,<sup>2</sup> the Cooglegong Tinfield presents a marked uniformity in its geology, the whole area consisting of granite, which in some places is gneissose in structure. The granite covers a wide expanse of country; it extends over an area of some hundreds of square miles, and, as may be seen by an inspection of the geological sketch map of the Pilbara Goldfield (Frontispiece), it appears to form part of the large mass which extends, with more or less interruption, from Corunna Downs to the Yule River. This mass embraces the country which took in the old Shaw River Tin-

<sup>1</sup> B.—Note more than  $2^\circ$  above or below  $15^\circ$  C. 1 c.c. solution acidified with H F holds 1.0 gm. on at  $15^\circ$  .00365 gms.  $Ta_2O_5$  as  $K_2TaF_7$ , or .00660 gms.  $Nb_2O_5$  as  $K_2NbOF_6$  (on .5 gm. of 73%  $Ta_2O_5$  and 7.3%  $Nb_2O_5$ ).

<sup>2</sup> A. Surv. Bulletin 15. Perth: By Authority, 1904, pp. 102 et seq.

field, which, so far as may be gathered from the official figures, has been responsible for 145·34 tons of tin, valued at £151,219.

As only four days were spent in the locality, there was little opportunity of doing more than making a very cursory inspection of the more salient features of the district as a whole. The western margin of the granite is in close proximity to White Quartz Hill, which forms the culminating point of the White Quartz reef, which has an average strike of 173° and forms one of the most conspicuous features in the landscape, visible for many miles in nearly every direction.

The granite is principally composed of quartz, felspar, mica, and presents a great uniformity in its composition over the whole area. As is the case elsewhere in the district, the granite is intersected in certain localities by veins of pegmatite, which are doubtless been the original source from which the stream tin and residual tin has been derived. All the tin hitherto obtained from the district has been derived from the alluvial deposits which have been formed in the existing valleys. So far as has at present been observed, these alluvial deposits do not attain any very great thickness, although their width must in many cases be very great.

As none of these alluvial deposits have as yet been geologically mapped, not very much can be said as to their extent, but there seem very good scientific grounds for the belief that systematic and judicious prospecting will result in the discovery of other deposits quite as rich as any of those yet opened up.

There is, in addition to the alluvial deposits, a fairly large quantity of residual tin, *i.e.* ore derived from the wear and tear of *in situ* of the tin-bearing pegmatite granites which traverse the portions of the granite massif.

Considerable interest attaches to the district on account of the occurrence of the mineral gadolinite, a silicate of yttrium, lanthanum, beryllium and iron, associated with the stream tin. The occurrence of gadolinite in granite from Cooglegong Creek was noticed in the Annual Report of the Geological Survey for the year 1900. Specimens [2027, 6495] of it are now in the collection of the Department. The presence of numerous pegmatitic granite dykes throughout the district, and the known occurrence of tantalum-bearing minerals in one at Wodgina (p. 273 *et seq.*) suggests the possibility of these being the matrix of the gadolinite. In other parts of the globe the rarer minerals, Thorianite, Yttrialite, Fergusite, Allanite, &c., have been found occurring in similar pegmatitic dykes, and there is but little doubt that careful search throughout the North-West district would result in the discovery of others of the rarer earths of which at the present there appears to be a considerable demand.

During the course of the field work search was made for a vein in which gadolinite is stated to have occurred, but without success. One very pronounced vein, 3 or 4 feet in thickness, upon which a little prospecting work had been done, was found.

<sup>1</sup> Ann. Prog. Rep. Geol. Surv., 1900. Perth: By Authority, 1901, p. 32.



large quantities of garnets, both in the massive form

analysis yet made of this gadolinite was made by  
of Sydney, and is as follows :—

SiO <sub>2</sub>	23·33
Protoxide, FeO	10·38
Barium Oxide, BaO	12·28
Barium Sesquioxide, Ce <sub>2</sub> O <sub>3</sub>	2·50
Barium Sesquioxide, La <sub>2</sub> O <sub>3</sub>	18·30
Barium Sesquioxide, Di <sub>2</sub> O <sub>3</sub>	33·40
Barium Sesquioxide, Y <sub>2</sub> O <sub>3</sub>	·69
Barium, MgO	·32
Barium Loss, H <sub>2</sub> , H <sub>2</sub> N, CO <sub>2</sub>	101·20

Specific Gravity . . . 4·14

*Table showing the Tin Yield of Cooglegong.*

Year.	Tin Ore Raised.	Value thereof.
	Tons.	£
. . . . .	65·06	3,687
. . . . .	174·43	8,880
. . . . .	91·80	6,373
. . . . .	173·59	12,541
. . . . .	114·34	8,664
. . . . .	141·13	12,034
Total . . .	760·35	52,179

g table shows the yield of the Old Shaw Tinfield,  
gathered from official figures :—

*Table showing the Tin Yield of Old Shaw.*

Year.	Tin Ore Raised.	Value thereof.
	Tons.	£
. . . . .	156·45	3,470
. . . . .	119·00	949
. . . . .	Nil	...
. . . . .	Nil	...
. . . . .	Nil	...
. . . . .	Nil	...
. . . . .	Nil	...
. . . . .	4·00	300
. . . . .	7·35	357
. . . . .	19·00	1,267
. . . . .	14·02	981
. . . . .	80·57	6,107
. . . . .	17·65	1,394
Total . . .	218·04	14,825

Mines Department records show only 2·75 tons, valued at £124.

### PART III.—GENERAL SUMMARY

The efforts which had been made by private enterprise to the development of mining in the Pilbara Goldfield seem to warrant such assistance and guidance as might be afforded. A reasonably accurate delineation of those salient geological features which had any bearing upon economic questions.

During the three field seasons spent in the district, visits were paid to, and such a detailed examination as the circumstances seemed to warrant made of, all the centres where mining was being, or had been, carried out. The three reports<sup>1</sup> may, therefore, be regarded as the results of an attempt at a systematic and reasonably detailed examination of the broader geological features of the Pilbara Goldfield, in so far as they have any bearing upon economic questions.

Whilst by far the larger portion of the reports is the result of my own personal observations, the manuscript reports of the Inspectors of Mines have been laid under contribution where considered necessary. The knowledge thus gained is graphically summed up on the general geological sketch map, which forms a frontispiece to this report.

The district affords better and more continuous sections than are generally to be met with on any of the goldfields of the West of Australia which have yet been examined; they thus reveal geological structures which are not to be found in the more scattered districts, and, on this account, serve to throw light on some obscure points in connection with the geology of other fields.

#### GENERAL GEOLOGY

The following is the geological record arranged in the form of a table, as furnished by the Pilbara Goldfield :—

Recent. . . . .	Blown Sand. Alluvium of the River Beds. Residual Deposits.
Oakover Beds . . . .	Sandstones, Limestones, &c.
(Age ?)	
Nullagine Beds. . . .	Sandstones, grits, conglomerates and volcanic rocks. ( <i>Gold bearing in places.</i> )
(Age ?)	
Mosquito Creek Beds	Grits, shales, and fine conglomerates bearing in places.)
(Age ?)	
Warrawoona Beds . .	Metamorphic sedimentary rocks, quartz conglomerates, greenstone schists, and allied rocks. ( <i>Gold bearing.</i> )
(Archæan ?)	
Granite and Gneiss . .	( <i>Tin and Tantalite bearing and also in places.</i> )
Dolerite, Diabase, and Gabbro Dykes.	

The OAKOVER BEDS have only been noticed, up to the present time.

<sup>1</sup> Geol. Surv. Bulletins, Nos. 15, 20, and 23.



country in the vicinity of the Oakover River, below Carawine. The beds consist of a series of sandstones, limestones, and which have yielded no fossils, and which are not very thick. The beds rest with a violent unconformability upon an older series of limestones and volcanic rocks. There is no evidence as to their geological age.

The NULLAGINE BEDS are largely developed in the Pilbara district, and consist of a great thickness of sandstones, grits, conglomerates, and limestones, some of which are magnesian, and interstratified with a series of lavas, ashes, and agglomerates of, as yet, undetermined thickness. The formation makes a prominent feature in the landscape of the district, and plays a very important part in the geology of the North-West. It may be followed from the Oakover River, across the upper reaches of the Nullagine, the Ashburton, and the Shaw Rivers, as far as the western boundary of the Pilbara Goldfield, on the Yule River, near Cangan Pool. Areas of more extensive extent make their appearance at Just-in-Time, Talga Talga, North Pole, on the Shaw. The formation is of some economic importance by reason of the fact that the basal members of the series are proved to be auriferous in two localities, several miles apart, Nullagine and Just-in-Time.

The Nullagine Beds cannot be exactly correlated with any of the series yet described in any of the previous official reports on the geology of Western Australia, owing to the absence of fossils throughout the series, wherever it has yet been studied. Under the present circumstances, petrographical resemblance seems to be the only method by which any clue can, in the present condition of our knowledge, be arrived at with respect to its age. In its lithological characters and general behaviour it bears a very strong resemblance to the quartzites, &c., which constitute that continuous formation extending from Wyndham to Mount Hart, a prominent summit on the Leopold Range in Kimberley, which have been claimed as Cambrian. If further research should indicate this resemblance to be of less greater significance than at present appears, the Cambrian age of the Nullagine Series would have strong claims for consideration.

The MOSQUITO CREEK BEDS, which underlie the strata of the Nullagine Series, comprise one of the oldest of the sedimentary formations as developed in Pilbara. The series consists of grits, conglomerates, and fine conglomerates, an approximate estimate of the thickness of which cannot be determined, though it is possible that the great thickness may be due to the repetition of the beds.

The base of the Mosquito Creek Series is not far from a little to the east of Nullagine in what are known as the Ashburton and South Dromedaries. The range in which the beds are developed consists of vertical beds of conglomerate of considerable thickness. The conglomerate is very much cleaved, and the bedding planes are seen to cut through the centre of many of the

quartz and other pebbles contained in it. The conglomerate contains numerous pebbles and boulders of laminated quartz (some of which form such conspicuous features in the Goldfield,

No trace of fossils has been met with anywhere in the district, so no definite data as to the age of the Mosquito Creek beds are available. Observations in the field have shown that these beds lie with a violent unconformity beneath the Nullagine beds. In certain portions of the district the Mosquito Creek Series has been subjected to more or less dynamical alteration, a considerable period must have elapsed between the deposition of the two series. The Mosquito Creek beds are of economic importance by reason of the fact that they form the matrices of the numerous auriferous quartz reefs which outcrop over a portion of the district, and which have been more or less perfunctorily worked.

**WARRAWOONA BEDS.**—In the neighbourhood of Warrawoona are a series of metamorphic rocks, which occupy a large area of country which forms a continuous belt from Marble Bar to Yandicoogina. These metamorphic rocks can be separated into two distinct sets, which are sharply differentiated from each other, an acidic and a basic series.

The acid series is made up of highly siliceous beds dipping at varying angles to the north-east and trending generally north-west and south-east. These beds, which there are very good reason for believing to be of sedimentary origin, consist of fine-grained quartzites, sheared conglomerates, which still retain traces of their original character, mica and quartz schists, together with fine-grained siliceous rocks, which seem to have lost all trace of their original character. There are in intimate association with these certain other acidic rocks, which may eventually prove on closer examination to be highly-sheared felsites. The basic series occupy a large area of country and vary very much in the way of their outcrop. A very important feature in this series is the presence amongst the beds of a series of unfoliated rocks, which sometimes occur in the form of lenticular belts of, in certain cases, considerable horizontal extent. In one or two localities are found magnetite schist, in the centre of some of which are unfoliated "eyes" of greenstone (of large dimensions), occurring in such a way as to indicate that the margins only have been crushed down to schist. The massive greenstones vary very much in grain; some contain more or less hornblende and its numerous alteration products; some of its constituent minerals being largely replaced by carbonates.

These Warrawoona Beds are traversed by bands of lamprophyre (chert (?)) which invariably occur in close proximity to, and in intimate association with, the auriferous quartz reefs.

The Warrawoona Beds are of considerable economic importance by reason of the fact that they carry all the auriferous reefs from Marble Bar, Salgash, Warrawoona, and Yandicoogina.



**GRANITE AND GNEISS.**—The Granite and gneiss, which occupies an extensive area of country throughout the field, is almost everywhere seen to be intrusive into the oldest rocks of the district, and is regarded as the Warrawoona Beds. In no case has the granite been noticed rising to the level of, and piercing the newer rocks of the Nullagine Series, hence its geological age can only be defined within certain limits. The granite is of importance in that it contains all the tin and tantalite veins of the district, the parent of the detrital tin of Moolyella, Old Shaw, Cooglegong, and Boodalyerri. The rich quartz reefs of Boodalyerri, and some in the neighbourhood of Yandicoogina, occur in these rocks.

**DIABASE, DIORITE, AND GABBRO DYKES.**—A series of greenish-grey dykes have invaded all the other strata below the Oakover in the form of dykes, which run in long and approximately parallel lines, and in many cases form very conspicuous features in the landscape, owing principally to their black weathered summits, which stand out in bold relief.

The dykes, which are all basic compounds, belong to two distinct periods. The newer basic dykes have a general north-east to south-west strike, and are often continuous for many miles. In many portions of the Goldfield the regular continuity of the system of dykes has been interrupted by faults, though no cases are under observation in which the horizontal shifting appeared very great. No very satisfactory evidence as to the age of the newer dykes has been obtained, though the Nullagine Series in the vicinity of the township of that name is pierced by them, thereby indicating that their age is post-Nullagine.

The older series of dykes have a general trend which is approximately at right angles to that of the newer system. Like the newer dykes they are all basic compounds, and in many cases they have been more or less crushed and sheared into schistose greenstones. Owing to the marked features which many of the dykes exhibit on the surface, they have proved of considerable value in working out the geological structure of the district in at least two of the mining fields.

## ECONOMIC GEOLOGY

The Pilbara Goldfield contains several gold and tin-bearing deposits scattered over different portions of the district. Economically, the auriferous deposits have proved up to the present to be the most important.

**GENERAL.**—The geographical position of the various gold-mining fields shows a zonal development of the auriferous deposits. From the result of the field observations, it appears that the auriferous deposits of the Pilbara Goldfield may be divided into two main and distinct groups, viz.:—

- (a) Lalla Rookh ;
- (b) North Pole, Talga Talga, Bamboo ;

- (c) Marble Bar, Warrawoona, Yandicoogina, Mt. Boodalyerri;
- (d) Nullagine, 20-mile Sandy, Mosquito Creek;
- (e) Tambourah, Western Shaw; and
- (f) North Shaw.

The length of the Lalla Rookh Belt has not yet been defined, but it does not appear to be less than 30 or 40 miles. The North Shaw, Talga Talga, and Bamboo Belt is 50 miles in length. The Marble Bar, Warrawoona, Yandicoogina, Mt. Elsie, and Boodalyerri Belt has a proved extent of about 80 miles. The Nullagine, Midland, and Sandy Creek zone is known to extend for a distance of at least 100 miles, and there are strong geological reasons for the belief that it continues much farther to the east, and may possibly cross the upper reaches of the Oakover River. The Tambourah and Western Shaw Belt has not as yet been accurately defined, but it does not appear to be less than about 30 miles in length, whilst that of the North Shaw has only been proved to extend for a few miles.

The general direction of these auriferous belts almost everywhere coincides with the strike of the schists, which, with two exceptions, invariably form the matrices of the gold reefs. The prevailing dip of the belts coincides with the prevailing trend of the main structural features of the district. Their strike naturally varies, and in the three most northerly zones, the strike cannot be defined owing to the fact that one of the bounding belts is invariably marked by a powerful fault, which throws down the newer beds against the schists.

Quartz reefs occur in great abundance all through the schistose rocks, as well as to a more limited extent in the areas occupied by the granitic rocks. The quartz reefs are of two distinct types: massive white quartz reefs and laminated quartz and jasper veins, appearing very closely the hematite-bearing quartzites (?), which invariably form a conspicuous feature in most of the goldfields of the district. Some of the laminated quartz veins range from almost pure quartz through banded jaspers, with crystals of magnetite, to hematite, appearing to the eye to be virtually pure hematite. Some of the reefs—particularly those in the Lalla Rookh Belt—could be readily concentrated to high-grade ores, which, under suitable conditions, might be turned to profitable account as sources of iron. The quartz reefs, of what may be called the massive type, occur plentifully in both the schists and the granites. They invariably occur along the planes of foliation (? bedding) of the schists, and at any rate, cut them at a low angle.

The auriferous reefs cannot be said to be long, and as a rule, small, though they occasionally swell out into large lenticular masses. Some of the reefs have been traced along the outcrop for over 2000 feet, and have swelled out to masses measuring a mile or more feet across.



ing table shows the gold yield from the different of the Pilbara Goldfield up to the close of 1905 :—

*the Gold Yield of the various Mining Centres of the Pilbara Goldfield up to the end of 1905.*

Centre.	Ore Crushed.	Gold therefrom.	Rate per Ton.	Total.		Average Rate per Ton.
				Ore Crushed.	Gold therefrom.	
	Tons.	Ozs.	Ozs.	Tons.	Ozs.	Ozs.
Ore.	6,532'50	7,547'84	1'15			
Ore.	418'00	277'02	'60	6,532'50	7,547'84	1'15
Ore.	779'15	1,496'23	1'92			
Alluvial.	..	50'26	..			
Dollied.	..	152'82	..			
Ore.	10,791'25	17,519'49	1'62			
Dollied.	..	119'70	..			
Ore.	8,941'31	15,210'32	1'70	11,986'40	a 19,292'74	1'61
Dollied.	..	135'34	..			
Ore.	283'40	734'69	3'14			
Dollied.	..	11'32	..			
Ore.	7,155'76	15,552'90	2'17			
Alluvial.	..	44'30	..			
Dollied.	..	335'73	..			
Ore.	2,686'25	5,521'47	2'05			
Dollied.	..	356'88	..			
Ore.	508'25	1,560'28	3'07			
Ore.	120'25	687'86	4'88			
Dollied.	..	148'85	..	19,645'22	b 39,167'52	1'99
Ore.	13,662'40	20,713'02	1'51			
Alluvial.	..	104'70	..			
Dollied.	..	81'93	..			
Ore.	2,282'00	5,802'59	2'54			
Ore.	5,779'99	9,156'47	1'58			
Dollied.	..	166'47	..			
Ore.	38'50	2,393'22	6'21			
Dollied.	..	1,529'32	..			
Alluvial.	..	2,161'24	..			
Dollied.	..	22'50	..	21,763'49	c 38,065'30	1'74
Ore.	2,077'75	2,536'88	1'22			
Dollied.	..	64'65	..			
Ore.	1,321'00	930'73	'76			
Dollied.	..	4'77	..	3,298'75	d 3,467'61	1'05
Ore.	351'45	674'72	1'91			
Alluvial.	..	7'53	..			
Dollied.	..	567'06	..			
Ore.	6'00	33'00	5'50			
Alluvial.	..	145'08	..			
Dollied.	..	15'17	..			
Ore.	101'00	49'63	'49			
Ore.	14'00	66'82	4'77	472'45	e 824'17	1'74
orted Ore.	237'95	1,099'71	4'62			
Alluvial.	..	4,109'29	..			
re-Alluvial.	..	1,435'44	..			
Dollied.	..	202'52	..	237'95	f 1,099'71	4'62
Total	..	..	..	63,936'76	g 109,464'89	1'71

ed. a Not including 50'26 ozs. alluvial and 272'52 ozs. dollied. b Not  
ial and 988'12 ozs. dollied. c Not including 3,795'26 ozs. alluvial and  
ot including 69'42 ozs. dollied. e Not including 152'61 ozs. alluvial and  
ot including 5,544'73 ozs. alluvial and 202'52 ozs. dollied. g Not including  
3,385'71 ozs. dollied.

The value of any reef being in a large measure influenced by its richness and its quantity, *i.e.* the thickness, length, and position of the shoots of gold, wherever possible, observations were made tending to throw any light thereon. So far as may be judged from the official returns from the various properties, it appears that the shoots of gold are rich, whilst the condition of the various workings implies that they are short.

The auriferous ores as a whole are of such a mineral character as render them readily amenable to battery amalgamation and cyanidation.

In addition to the gold derived from quartz reefs, the conglomerates at the base of the Nullagine Series have in two localities—Nullagine and Just-in-Time—been mined, and the gold, as shown in the tables below, obtained. It is noteworthy that the Nullagine series has only proved auriferous in those places where it lies upon that portion of the underlying formation which contains auriferous quartz reefs.

At Nullagine the auriferous strata occur through a thickness of about 300 feet of grits, sandstones, and conglomerates which form the lowest portion of the series. The auriferous conglomerate is of sedimentary origin, and is made up of rounded and sub-angular fragments of the underlying strata. Those portions of the conglomerate which have proved to be gold-bearing are those which are impregnated with the oxides and sulphides of iron, and which lie between a well-marked fault and a greenstone dyke. The operations have, up to the present time, been confined exclusively to the oxidised zone of the conglomerate and to very limited shallow depths. The available evidence regarding the origin of the gold seems to indicate that it is a secondary and not an original constituent of the conglomerate; and owed its introduction to the percolation of mineral-bearing solutions down the most porous portions of the conglomerate, this condition being facilitated by the downward inclination of the bedrock, and possibly accelerated in part by the folding which the strata have undergone. Numerous dryblowers have been at work for a number of years over a large portion of the conglomerate from which the crushings have been obtained, and have acquired a considerable quantity of gold, of which the published figures afford no clue. In all probability one-half of the "alluvial" gold from Nullagine may be legitimately claimed to have been derived from the escarpment conglomerate.

At Just-in-Time, 8 miles to the south of Marble Bar, the auriferous conglomerate at the base of the series has been worked. In many respects the auriferous conglomerate resembles the ferruginous bands as developed at Nullagine, and varies in thickness from an inch up to 5 feet in thickness. Certain portions of it contain a sufficient quantity of iron oxides to give it a distinctive character to the rock. The auriferous conglomerate of Just-in-Time is, however, not of any very great horizontal

appear to penetrate to any considerable depth. As case at Nullagine, the sloping ground at the foot ment has yielded considerable quantities of gold to , but, unfortunately, it did not appear to have been ep a separate record thereof. Most of the gold is way owed its origin to the disintegration of the

*Summary of the Yield of the Auriferous Conglomerates of the Pilbara Goldfield.*

Mining Centre.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Me . . . . .	5,167·00	3,217·29	·62
	60·00	47·30	·78
Total . . . . .	5,227·00	3,264·59	·62

various tables above give fairly reliable data as to of the reefs and conglomerates, the amount of om Pilbara can only be roughly approximated. The or which the district is famed are of distinctly local derived from the disintegration of quartz veins. ous zones of the Pilbara Goldfield resemble, in t respects, the gold belts of the Murchison and the elds of the State. Not only are the various rocks acter, but they may possibly be of the same geolo- t there is also the same linear persistence of the allel to the general trend of the dominant structural auriferous series.

tin deposits of the Pilbara Field, which have yielded of tin, valued at £140,689, are, with one or two of detrital origin. The deposits extend over a wide try, covering some hundreds of square miles, and vely exploited at several centres, many miles apart. known to occur in the granite area of Moolyella; the low percentage of cassiterite in the pegmatitic t has not yet been worked. The bulk of the tin from been obtained from the alluvial deposits which form alleys; they have, however, not been found to attain kness, though their width, in some places, exceeds addition to the alluvial deposits, a large quantity i.e. ore derived from the decomposition of the tin- ites, *in situ*, occurs, and has been responsible for no f the yield from Moolyella.

a, which was discovered in 1902, the tin occurs in



veins of pegmatitic granite, which penetrate a series of sandstone and bedded igneous rocks, occurring along its flanks. When these veins have been opened up, it is found that the tin is either wall, in a band consisting of mica and tourmaline in various proportions. The bed of the ravines, and the slopes on either sides, carry detrital and residual tin. The tin-bearing veins are numerous, though it yet remains to be proved whether they can be profitably mined. This centre bids fair to rise in the future as a tin-producer.

**TANTALUM.**—Tantalum-bearing ores have been found at Wodgina, and up to the end of 1905, 70·95 tons, value £151,219 have been raised. In addition to the alluvial and residual ores, which have yielded by far the larger quantity of tantalum, the mineral has been found occurring in pieces of large size in the pegmatite veins which traverse the field. Much of the tantalite results from the disintegration of the rich stannite vein. Having due regard to the uses to which the metal can be put, the discoveries at Wodgina are of importance, and seem every reason for believing that the area over which the mineral occurs will be extended.

It may be noticed in this connection that the various minerals and niobates of the rare earths, which exhibit marked properties, have been found to occur as primary constituents in such pegmatites as are met with at Wodgina; hence it is probable that careful search in the district may result in the discovery of the radio-active minerals, Thorianite, Lanthanite, Samarskite, Euxenite, &c.

*Table showing the Tin and Tantalite Yield of the Pilbara District up to the end of 1905.*

Mining Centre.	Tin.		Tantalite
	Ore Raised.	Value thereof.	Ore Raised.
	Tons.	£	Tons.
Cooglegong . . .	760·35	52,179	...
Moolyella . . .	1,261·72	86,048	...
Old Shaw . . .	145·34	10,530	...
Wodgina . . .	31·45	2,462	70·95
Total . . .	2,198·86	151,219	70·95

**DIAMONDS.**—The occurrence of small diamonds in the conglomerate at the base of the series at Nullagine has been noticed. At the present time, however, the interest is more scientific than commercial.

**IRON.**—Iron ores occur plentifully throughout the district. Many of those laminated quartz and jasper veins, now known as the Lalla Rookh zone, pass gradually into bands of what are



eye to be virtually pure hematite. Some of these deposits could readily be concentrated to high-grade ores. At present these are of course entirely beyond the reach of commercial enterprise, but, under more favourable conditions, there is little doubt but that some of them might be turned to profitable account as sources of iron ore.

**TUNGSTEN.**—An ore of tungsten, scheelite (tungstate of lime), has been met with in the lode occurring in the Ard Patrick Mine at Mosquito Creek. Two samples of this have been assayed in the Survey Laboratory, with the following results:—

- (a) 50·93 per cent. of tungstic acid ;
- (b) 45·1 per cent. of tungstic acid and 1 dwt. 15 grs. of gold per ton.

In both these samples, the comparatively low percentage is due to the admixture of a good deal of quartz with the scheelite. The mode of occurrence of the scheelite in the Ard Patrick seems practically identical with that in the Fraser's Mine, Southern Cross; Lindsay's Mine, Coolgardie; and the Record Mine at Norseman. Scheelite is marketable, and in this case it is merely a question of concentration, provided the ore occurs in such quantities to make it worth the expense.

**ASBESTOS.**—Asbestos is known from the district in the vicinity of Tambourah, but in what quantity or in what mode it occurs there is no definite information, as no official inspection of the locality has as yet been found possible. So far as may be judged from the specimens [1010, 6212] at present in the Geological Survey Museum, the asbestos from Tambourah turns out to be fibrous chrysotile, identical with the Canadian mineral which is so much valued. The Tambourah asbestos, unlike most of the Australian mineral, has not the great defect of a low tensile strength, and in all the points—infusibility, softness, flexibility, fineness, and the ease with which the fibres can be separated—is well above the average.

**LEAD.**—The occurrence of argentiferous lead ores is known from the neighbourhood of Tambourah, through specimens which have been sent in to the office for assay. No particulars regarding the ores are known to the Department than are to be gathered from the results of the official assays, which are as follows:—

Description of Ore.	Lead per Cent.	Gold. Ozs. per Ton.	Silver. Ozs. per Ton.
Cerussite, &c.	43·3	·736	22·69
"	60·1	<i>Nil</i>	88·31
Galena	64·5	Trace	68·75
"	68·8	Trace	75·07

## FUTURE PROSPECTS

The attempt to forecast the future of any mining district is all times a difficult matter, but more especially is it the case in any field where most of the mines are abandoned, full of otherwise inaccessible.

A correct judgment of the future capabilities of gold in Pilbara cannot, however, be formed if the fact is ignored that the auriferous quartz reefs are of that somewhat irregular character described in the pages of various reports. The reefs, however, give every indication of being permanent, whilst the returns from the mines up to the close of 1905, have been such as may be judged by the figures furnished to the Mining Commissioner, viz., 1·71 ozs. per ton of ore milled.

Far less genuine and judicious prospecting appears to have been done than the prospects of the field seem to warrant, although the auriferous quartz reefs are irregular, they are numerous and the wide-spread occurrence of quartz reefs, throughout different zones in the district indicate perfectly clearly the capabilities of the field, despite its relatively long existence, by no means exhausted.

It seems, therefore, that the past history of gold mining in the district will be its future history, viz., the discovery of small shoots in veins and reefs of the type described in the three reports, the exploitation of which seem best suited to the operations of small companies.

The auriferous conglomerates of Nullagine and Junction Hill, occurring at the base of such an extensive formation, though looked at from a broad point of view, low-grade local deposits of such a nature as would seem to encourage efforts in the direction of carefully prospecting other parts of the basal member of the series in the district. The area over which the formation is more or less accurately delineated upon the geological map of the field, which forms the frontispiece to this report, affords the opportunity of some assistance in this connection.

The very large area of intrusive granite in which tin has been worked in at least four localities, many miles apart, encourages careful and judicious prospecting, more especially those portions along the margin of the mass where it intrudes into the surrounding rocks, and if intelligently carried out there is every probability that other tin mining centres will be discovered.

If prospecting and mining operations are carried out in the Pilbara Goldfield with due regard to the prevailing geological conditions, it may be confidently asserted that the district will be a gold, tin, and tantalite producer.

A. GIBB MAITLAND,  
Government Geologist

## APPENDIX II

*Descriptive Register of Specimens from the Pilbara Goldfield (referred to in this portion of the report).*

No. of Specimen.	Registered No. of Microscopic Section.	Name.	Locality.
152	658	Quartzite . . . . .	Wodgina
160	...	Quartzite (iron-bearing)	Wodgina
196	687	Conglomerate (auriferous)	Just-in-Time
197	688	Conglomerate . . . . .	Just-in-Time
161	663	Mica slate . . . . .	Wodgina
153	659	Greenstone . . . . .	Wodgina
186	679	Greenstone . . . . .	South-east angle of Corunna, G.M.L. 272
191	684	Greenstone . . . . .	
192	685	Greenstone . . . . .	Main shaft, Tambourah King, G.M.L. 252
198	689	Vesicular andesite . . . . .	Just-in-Time
199	690	Andesite . . . . .	Just-in-Time
162	664	Hornblende slate . . . . .	Wodgina
185	678	Hornblende schist . . . . .	Tambourah
189	682	Greenstone schist . . . . .	Government Well, Tambourah
187	680	Granite . . . . .	Arrastra, Tambourah Creek
188	681	Granitic schist . . . . .	West of G.M.L. 274, Tambourah
190	683	Granitic schist . . . . .	Western Chief Lease, G.M.L. 568, Tambourah
166	...	Pegmatite . . . . .	Bull's Lode Claim, Wodgina
179	672	Pegmatite granite . . . . .	Main Lode, Stannum Mine, M.L. 77, Stannum Group, Wodgina
174	669	Porphyry . . . . .	Main Mass, Stannum, M.L. 77, Wodgina
175	670	Porphyry . . . . .	Main Mass, Stannum, M.L. 77, Wodgina
176	671	Porphyry . . . . .	Dyke in Greenstone, Stannum Group, Wodgina
180	673	Felspar porphyry . . . . .	Dyke in Greenstone, Stannum Group, Wodgina
155	661	Tourmaline rock . . . . .	M.L. 89, Wodgina
164	665	Tourmaline rock . . . . .	Commonwealth, M.L. 85, Wodgina
154	660	Blue quartz (quartz, lepidolite, and orthoclase)	M.L. 89, Wodgina
156	...	Tourmaline in quartz . . . . .	Wodgina
157	662	Manganotantalite (lode) . . . . .	M.L. 86, Wodgina
158	...	Manganotantalite (lode) . . . . .	M.L. 86, Wodgina
170	...	Manganotantalite (lode) . . . . .	Eadie's Claim, Wodgina
159	...	Manganotantalite (detrital)	M.L. 86, Wodgina
163	...	Cassiterite (lode) . . . . .	Main Lode, Cassiterite Mine, M.L. 84, Wodgina
165	...	Cassiterite (lode) . . . . .	M.L. 94, Wodgina
168	...	Cassiterite (lode) . . . . .	M.L. 84, Wodgina
171	...	Cassiterite (lode) . . . . .	Comet Mine, M.L. 80, Stannum Group, Wodgina
172	...	Cassiterite (lode) . . . . .	Stannum North Mine, M.L. 79, Stannum Group, Wodgina
177	...	Cassiterite (lode) . . . . .	Stannum Mine, M.L. 77, Stannum Group, Wodgina
194	...	Garnet . . . . .	Gadolinite Lease, Cooglegong
195	...	Gadolinite . . . . .	Cooglegong
197	...	Chloropal (var. pinguite)	Cassiterite Mine, M.L. 84, Wodgina
178	...	Tourmaline (blue) . . . . .	Tin Lode, Stannum Mine, M.L. 77, Stannum Group, Wodgina



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Victory East Extended Reef	...	...	...	...	...	...
Victory Extended Reef	...	...	...	...	...	...
Victory Lease	...	...	...	...	...	...
Volcanic rocks	...	...	...	5, 6, 16, 19, 20, 22, 23, 24, 25	107, 115, 123, 128, 130, 161, 2	...
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Walter's Folly Lease	...	...	...	...	...	...
Warrawoona	...	...	110, 111, 112, 130, 154, 155, 156,	163, 164, 165, 167, 168, 170, 171	202, 203, 205, 250, 286, 287, 288,	...
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**APPENDIX III.**

**REPORT**

**ON THE**

**PILBARA AND WEST PILBARA  
GOLDFIELDS**

**(With Special Reference to the Proposed Railway  
from the Coast to Marble Bar).**

**BY**

**A. MONTGOMERY, M.A., F.G.S.,  
STATE MINING ENGINEER.**









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## **Report on the Pilbara and West Pilbara Goldfields, with special reference to the proposed Railway from the Coast to Marble Bar.**

Office of the State Mining Engineer,  
Perth, 8th August, 1907.

*The Secretary for Mines, Perth, W.A.*

I have the honour to transmit to you hereunder, for the information of the Hon. the Minister for Mines, a report on the present condition of the Gold and Mineral fields of the Pilbara and West Pilbara Goldfields, with special reference to the projected railway from Port Hedland or other port on the coast to Marble Bar, or some other convenient terminus in the central portion of the Pilbara Goldfield.

I had the honour to accompany the Hon. the Minister for Mines on his recent journey through these fields. Leaving Perth on April 21st, we arrived at Port Hedland on 27th of the same month, leaving next day for Marble Bar, which was reached on May 1st. We then visited the Moolyella, Nullagine, Mosquito Creek, Warrawoona, and Mt. Edgar districts in the order named, returning to Marble Bar on May 11th. Leaving next day, we then went by North Shaw, Cooglegong, and Tambourah, to Wodgina, where over two days were spent. Leaving Wodgina on May 19th we went by Pilbara, Station Peak, and Mallina to Whim Creek, myself diverging from the route of the rest of the party to visit the Croydon and Towrannah fields. Two days were spent at Whim Creek and Balla Balla, and the party left for Roebourne on May 25th arriving on May 26th. The mines in the vicinity of Roebourne were visited between this date and the departure of the steamer on June 1st, which brought us back to Perth on June 7th. On following out this route on the map it will be seen that the trip was of the most flying character, and that no minute examination could be made of the country or of the mines, still it was sufficient to allow a good grasp to be obtained of the general position of affairs as regards the mining industry, and to become seized of the most important points to be considered in dealing with the railway proposition.

The examination of the country was greatly facilitated by the fact that it had already been minutely gone over by the Government Geologist, whose three reports, in Geological Survey Bulletins Nos.

15, 20, and 23, illustrated as they are with numerous maps and figures, give a very complete description of the structure and mine of the Pilbara Goldfield, and must form, for years to come, the basis of every general description of this region. The present report continually refers to these Bulletins, and contains much repetition of matter already published in them, and they should be constantly in the hands of anyone perusing it, for reference to the fuller descriptions and the maps and tabulated statistics given therein. Unfortunately the Government Geologist's report on the West Pilbara Goldfield has not yet been entirely completed and published, so that there is not the same information available with regard to it, but I have availed myself fully of the portions which have already appeared in the daily Press relative to some of the mining centres when compiling my description of these.

*Topography.*—The coast-line of the Pilbara Goldfields runs in an east-north-easterly direction, being thus nearly at right angles to the portion of the coast in the vicinity of Perth, and it is therefore necessary to travel in a more or less northerly direction to reach the coast by the nearest route from almost any of the mining centres. The general east and west orientation of these fields is often necessary to be recalled to the minds of those who are accustomed to the more or less north and south trend of the auriferous belts in our Central and Eastern Goldfields.

Along the coast the country is mostly composed of extensive sand-plains in the Pilbara Field, but in the West Pilbara these are smaller, and numerous rocky hills come right to the sea. For some miles inland from the coast these plains are usually composed of beds of detrital material of comparatively recent geological age, but they do not appear to be of great depth. The soil is a loamy sand, which on roads rapidly becomes worked up into a mobile condition, causing traction of vehicles to be heavy and difficult, and very tiresome to men or animals walking over it. Further inland the plains still continue for many miles, but are now found to be composed of granite, covered with only thin coatings of superficial drift, and they bear, distributed freely over them, numerous rocky hills and small ranges which stand up very abruptly from the plains like islands from a sea. Near Roebourne and to the north of Balla Balla these ranges run right out to the coast, and the plain country is not so much in evidence as it is to the south and south-east from Port Hedland. In this latter part of the district the great granite plain runs inland for about 60 miles before it meets any large area of hilly country. The plain is rising gradually as we get inland, but everywhere preserves its sea-like appearance, and there is no doubt in my mind that it represents a great plain of marine denudation, wherein the easily weathered main granite rock has been worn down by marine action to a general even level, above which the harder portions have been left standing up, at first as actual islands, and later on as steep hills. These granite plains can be traced

land to Yandicoogina on the north side of the Warrawoona Range, and by the flats of the Upper Turner River and Shaw Tinfelds to Gamma Downs on the south side of the same Range. Indeed, so far as I saw the country, the granite country coloured pink in the geological map of the Pilbara Goldfield in *Geological Survey Bulletin* No. 23 is mostly all portion of this great marine plain, though more and more studded over, as we come inland, with rugged abrupt hills of outstanding harder rocks. The general continuity of the granite plains is of the greatest importance in considering the question of railway routes, as they afford very easy country for railway construction. The soil on the granite country is, however, very sandy, making the roads over it very heavy for horse traction, and thus the ground which is specially favourable for railway making is anything but suitable for cartage roads without much expense in forming and gravelling these.

The geological map above referred to shows several areas of green colour, which are composed of very ancient metamorphic and greenstone schists, and all of which are regions of rugged rocky hills and ranges. One important outlying island of this sort forms the Wodgina Tinfeld, which is very steep hilly country, and others of similar character are seen to the north of it. The main green area shown on the map is a very extensive one, and represents very rugged country standing up high above the surrounding granite plains, but still with the same island-like appearance as the smaller one at Wodgina. The green areas therefore represent country which is necessarily difficult of penetration by railways. It, however, also represents the home of the auriferous and metalliferous reefs and therefore is of the greatest importance from a mining point of view. It is readily seen from the map that all the gold-mining centres are in the green areas with the exception of those between Nullagine and Mosquito Creek, which are in another ancient schist and slate formation. The geological map is therefore of great service in indicating by its colouring not only the geological structure of the country, but incidentally also the distribution of the minerals and the principal facts of the topography.

The Pilbara Goldfields are traversed by a large number of rivers. During the exceedingly heavy rains accompanying the cyclonic storms which at times burst over the district these streams often become wide and deep rivers, carrying enormous volumes of water, but in ordinary weather there is water in them only in detached pools sometimes long distances apart. The beds crossing the plains are wide and shallow, and carry great quantities of silt and sand. The forests of the region, such as they are, are almost entirely confined to these river beds and valleys, and consist of rather sparse and somewhat stunted and gnarled trees of river-bum, black-heart gum, bloodwood, and kadgebut, which furnish such good and mining timber as is available.

The plains and less rocky hills are plentifully covered with spinifex grasses of several varieties, which with interstitial grasses afford good pasture for stock, nearly the whole of the flatter country being in consequence taken up under pastoral leases as sheep and cattle stations. The excellent condition of the stock is a good revelation of the pastoral possibilities of this country to those who have not previously known of the value of the spinifex as fodder. Stocking of the plains with sheep seems to be proceeding very rapidly, the pastoral industry having made great advances of recent years.

*Geological Structure.*—No description of these mining fields can dispense with some reference to their geological structure, and though this has been described in detail in the Government Geologist's Bulletins, and is referred to in the present report in the accounts given of the various mining districts, it seems advisable at this stage to present a short summary of the principal geological features.

The oldest rocks in the Pilbara Goldfields are those coloured green on the geological map in *Bulletin No. 23*, which have been termed the Warrawoona Series by the Government Geologist. They are highly metamorphic schists and more or less schistose igneous rocks, which have been so highly plicated that they are now found almost always dipping at very high angles, and much faulted. They occupy a large area in the centre of the Pilbara Field, and are the principal home of the auriferous and cupriferous lodes. The lodes very generally lie more or less parallel to the foliation of the schists which varies very greatly in strike in different parts of the area. The strike very frequently is approximately parallel with the contact of the schists with the granite surrounding them, a fact of considerable significance from the point of view of structural geology, but not worth dwelling upon for our present purpose. This series of rocks is probably of much the same age as the greenstones and dioritic schists of the Eastern Goldfields of Western Australia, to which its igneous members exhibit great similarity in composition and appearance.

The next series of rocks in point of age are those shown in yellowish-brown colour on the Geological map, occupying a large area from Nullagine eastward to the Oakover River, and termed by the Government Geologist the Mosquito Creek Beds. There is some evidence that they are younger than the Warrawoona series and though highly plicated they do not seem to have suffered such intense pressure and metamorphic action as the older rocks, and are therefore much less crystalline. They also contain auriferous rocks which have a tendency to conform generally in strike with the strata enclosing them.

The great granite formation which is far the most extensive of any in Western Australia not only in the Pilbara fields but also



outh of them, is shown in pink colour on the Geos clearly younger than both the preceding series of which it intrudes frequently. Quartz reefs are but except in close proximity to the greenstones it they have rarely, if ever, been found to contain some of the fields it is noteworthy that the auriferous both greenstone and granite country indiscriminately that they were formed subsequently to the main granite. The granite is frequently stanniferous, being traversed by pegmatite dykes or veins carrying tin ores.

Older rocks are traversed by numerous dykes of several different varieties and ages—porphyrites, diabases, and gabbros. The diabase dykes are black-topped rocky ranges running for many miles in the country, and may have some connection with the Nullagine series to be mentioned presently. No distinction has yet been made out between any of these and the occurrences of minerals in the districts traversed—they point to the general fact that the older rocks have been repeatedly subjected to igneous intrusions, and have lost their usual concomitant of hydrothermal action commonly held to be favourable for the formation of auriferous lodes. A stronger and much more direct evidence of hydrothermal action is afforded by another set of veins very common throughout the Pilbara fields, and also in the Central and Eastern Goldfields. Sphalerite and pyrite quartzites seen in nearly all the geological districts of the Pilbara fields, and particularly prominent in the district of the Murchison and Cue in the Murchison field. The celebrated auriferous reefs in the Coongan River is one of the best known of the very common, and are frequently in very close proximity to the auriferous reefs, with which there is some reason to believe they may often be genetically connected. They are of a peculiar character, being most probably zones of fracture along which hydrothermal and pneumatolytic action has taken place, with the deposition of silica and oxide of iron in veins, and the simultaneous removal of most of the more soluble material, the original material and replacement of them by silica. They are very commonly found throughout the country close to the contact between the Warrawoona series and the intrusive granites, suggesting that they are of the same age, but numbers are also found traversing the country when no granite is visible in the near vicinity. "Auriferous reefs" have not been found in the Pilbara fields to the same extent as in the Central and Eastern Goldfields, but they have significance as to the agencies which have formed them in the districts where they occur the agencies have been worked out to which are usually ascribed the formation of auriferous reefs.

All the rocks hitherto mentioned, including the bars, but excepting some of the newer basic dykes, are of geological antiquity, probably at any rate pre-Cambrian, entirely Archaean. We have now to mention, however, a younger series of beds which cover large areas of the Nullagine fields, and which have been named the Nullagine by the Government Geologist. These are strata of conglomerate sandstones, and shales interbedded and overlaid by thin and fragmentary deposits, which lie more or less horizontally on denuded upturned edges of the older strata. They have been subjected to slight bending through earth movements, but rarely show any considerable plication. They are composed of detritus of the older formations, and contain fragments of auriferous veins belonging to these, showing them to be of the date of formation of the auriferous lodes. Gold is found in some of the conglomerates of this series at Nullagine. Time under circumstances similar to those of its occurrence in the "banket" reefs of South Africa, and the copper-bearing strata of the Whim Well Company, at Whim Creek, is also vouched for by the strata of the same formation. Apart from these metals, this series of rocks does not appear to be a mine. In the Geological Survey Bulletins above-mentioned, the date of the Nullagine beds is tentatively put down as Cambrian. In his recent address to the Australasian Association for the Advancement of Science, at Adelaide in January last, the Government Geologist has altered this to Devonian.

The geological map shows two or three small areas of probably still younger rocks near the Oakover River, composed of sandstones, limestones, and cherts of uncertain age, but not known to be of any economic importance. These rocks so far inland may be of some importance in enabling us to arrive at of the conditions under which the Nullagine plain might have been formed by marine action.

The coastal formation of sandstones, incoherent limestones is probably of rather recent geological age, but of it may date back to Tertiary or even Cretaceous, but of not of importance for our present investigation.

In the detailed description of the various fields, further reference is made to the geological structure, and it seems necessary to explain the mode of occurrence of the deposits.

#### DESCRIPTION OF THE MINING DISTRICTS

Before proceeding further with discussion of the various railway routes it will be of advantage to discuss the various mining centres in some detail, after which we shall be in a better position to discuss the

improve their working facilities by removing the dis-  
 sive hitherto stood so much in the way of the develop-  
 ment of the goldfields, and which will be best understood after  
 the conditions of the individual cases separately.  
 The notes the districts are not described in the actual  
 they were visited, but as they would be traversed by  
 going at Roebourne and going eastward through the  
 to Creek.

#### ROEBOURNE DISTRICT.

Every round Roebourne has long been known  
 with gold, copper, and lead in them, and  
 work has been done from time to time for many  
 years. It is only lately that there has been any considerable  
 prospecting in this very promising district. This is some-  
 thing, seeing that owing to its proximity to the coast we  
 must not expect that there would not be the serious difficulties in  
 the way of transport of timber, machinery, and supplies that  
 have hampered the development of mines inland, and  
 that there would have been steady progress in mining.  
 It has, however, never to have attracted much attention  
 from the public outside and to have been left mostly to the  
 local residents to develop. Notwithstanding its proxim-  
 ity it has not been by any means an easily accessible  
 district. Arriving by steamer had to be transhipped in Cos-  
 sack lighters, brought by them up a tidal creek to Cossack  
 and then carried by horse tramway to Roebourne. The  
 construction of a deep-water jetty at Point Sampson has  
 enabled vessels to discharge on to it, but as there is no practi-  
 cable wheeled traffic from Point Sampson to Roebourne it  
 is necessary to send goods by lighters to Cossack as before.  
 The construction of a tramway from Point Sampson jetty to join  
 the Cossack tramway is very urgently required, and  
 would be a great boon to the district. Steamers are able to lie  
 at the Point Sampson jetty and take in and discharge cargo  
 at low tide and in most weathers, there being  
 less than ten or twelve days in each year—according to  
 the season—given to me—on which the sea is so rough as to  
 prevent remaining alongside. The extension of the tramway  
 would enable rapid despatch to be given both in exporting  
 goods, doing away with the delays and costs of  
 transhipping at Cossack. At present it costs 21s. a ton to carry  
 goods, from the tramway shed at Roebourne via Cos-  
 sack and lighter and put it on the coastal steamers in  
 Fremantle. Such serious shipping and landing charges in  
 the coastal freight of 20s. a ton to or from Fremantle,  
 a considerable portion of the costs of realising ore and  
 of bringing supplies.

In the immediate vicinity of the town of Roebourne the country is mostly massive diorite of a coarsely crystalline structure, but which changes to a somewhat fine-grained variety of the same rock to the south and west of the town in the vicinity of the copper mines. There are also occasional intrusions of felsite. Further west the country is principally laminated schist with high angles of dip which may be diorite schist or perhaps a metamorphic schist, probably of Archaean age, especially well seen at Nichol Bay. To the east and south-east of Roebourne granite is found, and is seen at intervals all along the road to Whim Creek, appearing to be the principal rock formation, but is broken in places by wide intrusions of the coarsely crystalline diorite, as at Sherlock Station and close to Whim Creek. Several large outcrops are seen in the district of hematitic jasperoid "bars" referred to in the above geological sketch. One very excellent sample is seen at the shore end of Point Sampson jetty, the outcrop of the bar running north-north-easterly in a nearly straight line for a long distance. Another great outcrop of the same sort forms the hills on the south-east side of the gold workings at Weerianna, and another is seen to the north of the Carlow Castle mine.

#### LEAD MINES.

*Brother's United M.L. No. 67.*—About seven miles South of Roebourne and very close to the junction of the granite country with the diorite several mineral leases have been taken up or applied for, the principal one being the Brother's United M.L. 67. On this there is a long well defined reef running nearly due North and South in hard crystalline diorite country, evidently a true fissure vein. It has an Easterly underlay, and is said to be from four to six feet wide in the workings from a shaft which has been sunk, but which was full of water at the time of my visit. The outcrop is very easily traceable as a distinct line of quartz, often several feet in width. The shaft is said to be 30 feet deep, and there has been a little driving done from it North and South on the course of the reef. The lode matter is principally quartz, but at the shaft and in some trenches South and North of it there is a good deal of galena and some blende in the stone, and near the surface considerable carbonate of zinc and a little green carbonate of copper. Mr. Woolcock, the owner of the lease, told me that he had had a bulk assay of the galena ore heap which returned 54 per cent. of lead, and that the assays in silver ran from four to six ounces to the ton, with a little gold. The ore, however, that I saw in the paddocks would require very careful picking to yield a marketable product, and most of it would require concentration by dressing machinery. Galena is seen in several cuts on the outcrop of the lode, the furthest North of them being a shallow shaft about 50 chains North of the main workings. I took a sample of the cleaner galena from the various cuts

while passing along the outcrop in order to ascertain approximately its average value in gold and silver, the sample returned—

	per cent.
Moisture ... ..	0·16
Silica, $\text{SiO}_2$ ... ..	16·08
Alumina $\text{Al}_2\text{O}_3$ ... ..	1·23
Iron, Fe ... ..	·85
Zinc, Zn ... ..	·61
Copper, Cu ... ..	·42
Lead, Pb ... ..	67·07
Sulphur, S ... ..	12·93
Oxygen, carbonic acid, O, $\text{CO}_2$ , etc. ... ..	·65
	<hr/> 100·00 <hr/>

Equal on the dry ore to—

	per cent.
Copper ... ..	0·42
Lead ... ..	67·17
Silver ... ..	3ozs. 18dwts. 10grs. per ton
Gold ... ..	trace

A sample of the Carbonate of Zinc ore was also analysed, giving—

	per cent.
Moisture ... ..	0·15
Silica, $\text{SiO}_2$ ... ..	14·33
Alumina, $\text{Al}_2\text{O}_3$ ... ..	1·90
Magnesia, $\text{MgO}$ ... ..	·58
Lime, $\text{CaO}$ ... ..	trace
Iron, Fe ... ..	1·25
Zinc, Zn ... ..	38·14
Copper, Cu ... ..	·25
Lead, Pb ... ..	3·51
Sulphur, S ... ..	1·00
Oxygen, carbonic acid, O, $\text{CO}_2$ , etc. ... ..	38·89
	<hr/> 100·00 <hr/>

The assay on the dry ore was—

	per cent.
Copper, Cu ... ..	0·25
Lead, Pb ... ..	3·51
Zinc, Zn ... ..	38·20
Silver, Ag ... ..	10dwts. 21grs. per ton
Gold, Au ... ..	22grs. per. ton

The Zinc is equal to—

	per cent.
Carbonate of Zinc, $\text{ZnCO}_3$ ... ..	69·22
and	
Sulphide of Zinc, $\text{ZnS}$ ... ..	3·04

From these analyses it is seen that the ore is poor in the precious metals.

Near the North workings a branch lode is seen to the Eastward, going off on a more North-Easterly course. A shaft has been sunk some 12 to 15 feet on this, but the ore did not seem to me to be at all promising.

Close to the North shaft the lode and enclosing diorite country are both penetrated by a more recent dyke of fine-grained basalt, about 10 inches thick, which however does not fault the quartz reef appreciably.

Though this lode contains some fair galena and may improve when opened up, it did not seem to me to be of very much promise, the low value of the galena in precious metals, the presence of considerable zinc, and the necessity for concentrating most of the ore being all against it. It certainly deserves more prospecting than it has yet had, in the hope that there may be richer shoots of ore in it, but there is not yet much encouragement to open out with permanent mining work. There is a good deal of water at rather shallow depth in the Southern workings, and Mr. Woolcock told me that he found the influx too great to be coped with by manual labour alone, so that even for proper prospecting a light steam pumping plant would be of much advantage.

#### COPPER MINES.

*Fortune M.L. No. 64, Aurora Australis M.L. 93 and Aurora Australis West, M.L. 94.*—These three lease applications are taken up on the lode formerly worked on gold mining leases 60 and 61 by the Glenroebourne Gold Mines. The Fortune is a small holding taking in a large quartz outcrop and the principal old workings, and the other two leases are East and West of it. The big quartz outcrop stands out prominently from the flat valley in which it occurs, and the reef has been traced a short distance North-East from it and for nearly a quarter of a mile to the South-West, part of this distance being, however, possibly on a parallel lode. The course is about North 60 degrees East, and there is a slight underlay to the North. The old workings were not accessible at the time of my visit except some close to the surface, which have recently been reopened, and from which some very fair copper ore had been extracted. The country is schist, lying in a belt parallel with the lode between large masses of crystalline diorite, the schist being very likely a portion of the diorite rendered schistose along a shear-zone. The lode has well-marked smooth walls, and consists mostly of quartz, often stained with oxides of iron and copper and carbonates of copper. In places the lode is as much as 20 feet wide, but the average is four to six feet, and the valuable ore-bearing material is usually confined, as far as can be seen at present, to portions only of the whole width. The owner of the "Fortune" ground, Mr. Watson, has collected a few tons of good copper ore, mostly carbonate and "liver" ore, and has shipped about four tons recently which gave a net return of £125. There are old shafts on this lease said to be down 60 feet and 40 feet, and a good deal of work must have been done in former days. There is a good deal of second-class ore about the surface that would probably be worth



putting through a local smelter, and probably a considerable amount could still be got from the old workings without opening much fresh ground.

In the "Aurora Australis West" there is an old shaft down some 60 feet, but all the recent workings are shallow. A few tons of picked ore have been stacked ready for shipment. In this lease there is what I take to be a strong heave of the reef to the North-West a distance of some 80 feet or so, or else there are two parallel reefs *en echelon*, one dying out and the other beginning opposite to its Western end but further to the North-West. On the West side of the heave there are several old shafts and workings which were probably made for gold, as the lodestuff in this part does not seem to carry very much copper, though often distinctly stained with it.

In the Government Geologist's Report of 29th August, 1906, on these mines it is stated that some of the ore outcropping in G.M.L. 61 assayed in the official laboratory 16.07 per cent. of copper. The easternmost of the two leases, G.M.L. 61, which was at one time known as the Glenderry, produced in 1901 22 tons of copper ore, valued at £287.

To get some idea of the suitability of the ore for smelting purposes I took a "grab" sample of the picked ore in some of Mr. Watson's ore heaps, which gave the following analysis :—

				per cent.
Moisture	..	..	..	1.30
Silica	..	..	..	29.09
Alumina	..	..	..	.64
Magnesia	..	..	..	.69
Lime	..	..	..	trace
Iron	..	..	..	25.12
Nickel	..	..	..	.23
Copper	..	..	..	18.15
Lead	..	..	..	trace
Sulphur	..	..	..	1.27
Oxygen, carbonic acid, etc...				23.51
				100.00

Equal on the dry ore to—

Copper	..	..	..	..	18.39 per cent.
Silver	..	..	..	..	5ozs. 0dwts. 8grs. per ton.
Gold	..	..	..	..	2dwts. 13grs. per ton.

The analysis shows the sample to have been of excellent composition for easy smelting, being practically self-fluxing.

This is a strong lode and seems well worth opening up, but it is a great pity that information is not now available as to what was found out about it when the mine was originally opened.

About 12 chains (estimated) South of the above lode there are some fairly deep workings on a line of reef running about North 80 degrees East on what was formerly the Surprise lease, No. 132. and to the West of it. Two shafts are said to be down 70 feet, and the reef though rather small has been followed for about half a mile, though possibly not continuous. This reef also seems to be in a belt of schist traversing the diorite and probably in reality a zone of shearing in the latter. The reef is a large mass of quartz at the East end but only about 18 inches wide in the Western workings. No one was working on this reef at the time of our visit. A little copper is stated to have been sold from this reef and to have been found to carry gold. I took a grab sample of the quartz lying at the Western shaft to try for gold, but on assay it was found to contain neither gold nor silver.

*North and Brown's P.A.*—To the North of the Fortune Mine there are several copper-bearing lodes known to exist, several of which are shown on the Government Geologist's map accompanying his Report of 29th August, 1906. They strike more or less East and West, but very little can be seen of them at present. Messrs. North and Brown have reopened one of the old shafts, sunk some 40 years ago, and deepened it to 70 feet. The lode is only about 18 inches wide at surface, but at the bottom of the shaft it is  $3\frac{1}{2}$  feet wide. The strike is North 80 degrees West and there is a slight underlay to the South. The walls are smooth and well defined, the country being a thin belt of greenstone schist in crystalline diorite. Near surface the lode carries oxides and carbonates of copper, but these soon give place to chalcopyrite and marcasite. In the bottom of the shaft there is some sooty black sulphide of copper mixed with pyrites a sample of which, given to me by the owners, on assay yielded :—

				per cent.
Moisture	..	..	..	0.40
Silica	..	..	..	27.93
Alumina	..	..	..	7.47
Magnesia	..	..	..	3.00
Lime	..	..	..	trace
Iron	..	..	..	16.12
Nickel	..	..	..	.72
Copper	..	..	..	23.95
Sulphur	..	..	..	17.96
Oxygen, carbonic acid, etc...				2.45
				-----
				100.00
				-----

on dry ore to—

..	..	..	..	24.05 per cent.
..	..	..	..	6ozs. 10dwts. 16grs. per ton.
..	..	..	..	5dwts. 11grs. per ton.

er sample taken by myself from the cleaner chalcopyrite  
ace was also analysed, yielding—

				per cent.
Moisture	..	..	..	0.19
Silica	..	..	..	18.98
Alumina	..	..	..	trace
Magnesia	..	..	..	.22
Lime	..	..	..	trace
Iron	..	..	..	30.94
Nickel	..	..	..	.79
Copper	..	..	..	15.25
Sulphur	..	..	..	28.02
Oxygen, carbonic acid, etc...				7.61
				-----
				100.00
				-----

say on dry ore being—

..	..	..	..	15.28 per cent.
..	..	..	..	2ozs. 5dwts. 18grs. per ton.
..	..	..	..	3dwts. 19grs. per ton.

ners informed me that two tons of the ore sent to market  
per cent. of copper, and that they had since shipped 11  
but had not then received the assay returns. They had,  
en informed that owing to the presence of marcasite the  
somewhat poor. The second analysis quoted shows cop-  
comparison with iron and sulphur.

bottom of the shaft this lode seems a nice strong little  
ell worth opening up. There are, however, about 1,500  
hour of water to be raised, which hampers the pro-  
y much.

Australia, M.L. 114 (*Application*).—About six chains  
-West from North and Brown's shaft some work has

been begun by Machin and party on another East and West lode containing oxides and carbonates of copper, but the size of which could not be clearly seen.

Some seven or eight chains still further North-West there are some old workings in which is visible a strong lode formation about six feet wide between its walls, also running roughly East and West. In one cut on this there was a small vein on the South wall of rich copper sulphide (chalcocite or copper glance).

*The Roebourne Copper and Gold Mines, W.A., No-Liability: Carlow Castle Mine M.L.65 (formerly M.L.14).*—There are six lodes distinguishable on this lease most of which were first opened up in former years and abandoned after a good deal of ore had been raised. They are now being again re-opened, but little new work had been done at the time of my visit. In the North-West angle of the lease there is a lode known as No. 1 or the "big" lode, on which there is an old shaft said to be 70 feet deep but now filled up to 50 feet. The lode is probably quite eight feet wide between its walls, but is not clearly seen and is composed of schist and quartz much stained with oxides of iron and carbonates of copper. At the 50 feet level a crosscut about six feet into the West wall of the shaft showed that this was still lode matter, and a seam was cut of very nice chalcocite ore, well worth following. With this exception, the lodestuff visible was poor in copper. To the South-East from these workings are others on No. 7 and No. 2 lodes, the latter being also called the "main" lode. It runs a little West of North and probably joins the No. 7 lode, which runs North-Easterly. There is a whip shaft 60 feet deep on the main lode, but at the time of my visit there was about 10 feet of water in it. Considerable stoping seems to have been done. The ore on the dump is quartz and oxide of iron containing frequent specks of native copper and a little oxide and carbonate of copper. Some of it also shows gold pretty freely. The lode is about four feet wide and in diorite country. The ore is silicious on the whole, but some of it contains so much oxide of iron as to be of good smelting quality, and seems likely to be worth sending to a local smelting works though too poor for shipment.

No. 3 lode is one found towards the North-East angle of the lease running North-Westerly, on which there is an old shaft about 75 feet deep and considerable old workings. The lode is about three feet wide and very fair oxide and carbonates of copper are said to have been got from it. I was told, but am without verification of the statement that one of the last parties who worked it made a profit of about £2,000 from their produce. From the appearance of the old workings it would seem likely that a fair shoot of ore existed

at this point and was worked down to the water level, but at present one cannot see if it continued in the bottom of the workings.

Lodes 4, 5, and 6 run North-Easterly, and but little work has been done on them. At No. 4 there is some fair ferruginous oxide and carbonate of copper ore, fit for shipment, and Nos. 4 and 5 lodes show copper-stained material.

At the time of my visit the present owners had shipped six tons of ore from the mine, but had not received the smelter's assay returns. The ore was expected however, to give less than 20 per cent. of copper.

The official returns recorded by the Mines Department from the Carlow Castle Lease are 159 tons of ore raised, valued at £2,459; there is, however, no certainty that these returns are by any means complete. The lease seems well worth further opening up. As will be seen from the following extract from the Government Geologist's Report of the 29th August, 1906, the copper ore is stated to contain quite appreciable values in gold

"Samples of the ore from the North-West vein, which outcrops on the North-East corner of the property assayed in the official laboratory (6424, 6425) 12.77 and 34.22 per cent. of copper.

"In 1898 the files of the *Northern Public Opinion* mention two shipments of copper ore from the 5-Mile Copper mine, viz. : (a) 9 tons giving a return of 31 per cent. of copper and 3dwts. of gold, and (b) 1½ tons yielding 16 per cent. of copper and 1½ ounces of gold per ton.

"The same paper states, in February, 1899, that the mine was sold for £32,000, but in the month of July work ceased owing to the influx of water. A small syndicate of Roebourne residents appear to have worked the mine in 1900, and about 20 tons of ore were bagged and shipped. The ore is stated to have assayed as high as 30 per cent. of copper. In the month of February of the following year, 30 tons of ore were sent to Adelaide and Fremantle for treatment, and are reported to have yielded 24 per cent. of copper in addition to 14dwts. of gold.

*Lily Blanch Mine, M.L. 77.*—This mine is situated about two miles west from Roebourne, on some small diorite hills. A lode has been found on it running nearly north and south, which has been opened by two shafts to a depth of 40 feet. At surface the lode was very small, the outcrop being almost imperceptible, except for occasional copper stainings on the rock. On sinking, however, upon it, it soon opened out, giving at first some very fair oxidised copper

ore, which soon changed to chalcopyrite. A shoot of ore about 76 feet long has been stoped, the lode averaging about five feet in width of ore mostly worth saving. In one place, however, I noticed a "splice" of poorer iron pyrites on one of the walls. The walls are smooth and distinct, the lode being a fissure vein cutting through the enclosing diorite country. In the bottom of the north shaft it was three to four feet wide, when I saw it, there being nearly three feet in width of clean chalcopyrite ore. Elsewhere there is some quartz gangue and "horses" of country, and the lode is in places as much as eight feet wide. The workings are not yet extensive, but the ore has been so good that the mine has been a very profitable one to its owners, and when I saw it there seemed every prospect of its maintaining a fair output of ore. The owners informed me that they had raised since February last about 400 tons of ore containing about 24 per cent. of copper, and 20 tons estimated at 12 per cent. They had lately shipped 81 tons averaging 26.8 per cent. of copper, and had another good parcel on the wharf waiting shipment. Twenty-one men were being employed underground and about 10 on surface, and £1,580 had been paid for wages alone.

The official returns from this mine to 30th April, 1907, show 303 tons of ore shipped valued at £6,060, containing 60.60 tons of metallic copper, or an average of 20 per cent.

The present workings are just upon the water level, and machinery will soon have to be provided for raising the water in order to allow deeper sinking. This mine is at present the mainstay of the Roebourne Copper Mining industry, and much depends upon its success.

*Ena M.L. 68.*—According to the lessee there are seven lodes on this lease, on which a little prospecting has been done. One of these runs north 50 degrees east, and has little underlay. Its immediate walls are greenstone schist, but this changes quickly into the ordinary massive diorite of the country at a little distance from the lode, the schist being apparently simply the diorite rendered schistose along a line of shearing. The shallow trenches on the outcrop show about two feet in width of rubbly iron and copper-stained quartz. Ten tons of picked ore from this and other lodes on this lease are said to have returned 15 per cent. of copper on bulk assay. To the north-east of these workings there are two lodes close together, running about north 20 degrees east, which show some fair-grade ferruginous oxide and carbonate copper ore. East from these workings is a fairly long line of lode running north 10 degrees east, which has been traced over a somewhat steep hill. At the north end of this outcrop a shaft has been sunk 30 feet deep, in poor ore. I was informed, however, that there were about three feet of ore in the bottom of the shaft, but could not get down to see this. Cuttings



into the outcrop south of the shaft showed copper-stained rubbly lode matter, from which a small amount of fairly good oxide ore could be got. This lode could very readily be prospected by driving a tunnel along its course from the gully at its south end.

The Ena lodes are, as yet, very little opened up, and do not show much ore; but they seem well worth further prospecting.

*Proposed Smelting.*—It will be seen that with the exception of the Lily Blanch none of the Roebourne Copper mines are at present regular producers of copper ores to a serious amount, though some are very promising prospects. As they are more opened up, however, the question of the treatment of the ore will become of increasing importance, and already the mine owners are making inquiries as to cost of smelting plant of reverberatory and blast furnace type. In this, as in most other districts, it is all very well to begin with shipment of the richest ores, but there soon come to be accumulations of poorer stuff that will not pay for shipment, but which could be treated locally either by concentration for shipment in the case of some sulphide ores, or by local smelting. The sulphide ores of the Roebourne District would be of great value in smelting the poorer classes of oxidised ores at Whim Well, and it seems possible to make arrangements whereby the cost of transport from the mines to Point Sampson jetty and thence to Balla Balla would not be excessive, but unless this could be done very cheaply it would probably soon be preferable to smelt near Roebourne. If active prospecting work continues to be carried on in the district, it should be possible very soon to come to a conclusion as to when the establishment of a local furnace would be justified. As soon as there is reasonable certainty that supplies of ore will be forthcoming sufficient to keep a furnace in fairly constant operation, every encouragement should be given to any person or company proposing to establish such.

The officially recorded returns of copper ore from the Roebourne District are shown in the following General Table of copper production of the West Pilbara Goldfield.

#### GOLD MINES.

The copper ore of this district seems usually to carry a little gold, though often rather poor in the precious metal, and it has been above noted that the gold values in the Carlow Castle stuff are often considerable. There are, however, also mines in the district whose value is in gold alone, the reefs being fairly clean milling ore, with only occasional stains of copper carbonates. It remains to be seen if there is so much copper as to interfere seriously with cyanide treatment; at present the mines are not opened up enough to give a definite opinion on this point. The gold mines seem to be in the schist country, which is probably diorite schist, but may possibly be found to belong to the Mosquito Creek formation of the geological survey.

*Copper Production of the West Pilbara Goldfield*

Locality.	No. of Lease.	Registered Name of Company or Mine.	Previous to 1899.		1899	
			Tons of Ore.	Value. £	Tons of Ore.	Value. £
Roebourne .. ..	14	Carlow Castle Copper Mine ..	85	1,190	48	8..
	42	Federation (now part of same ground as Carlow Castle)	..	..	..	..
	49	Glenderry .. ..	..	..	..	..
	77	Lilly Blanche .. ..	..	..	..	..
Whim Creek .. ..	34 (5.12) Freehold 100 acres Loc. 71	Balla Balla Copper Mine .. F. W. Prell & Co. (now Whim Well Copper Mines. Ltd.)	6,638	49,785	1,405	4,948
	10	Rushall's Lease .. ..	20	150	..	..
	33	Stranger's Copper Mine ..	..	..	10	100
Croydon .. ..	26	(Croydon Copper Mine) ..	15	245	25	35
	31	Evelyn Copper Mine (now British Exploration of Australasia, Ltd.)	..	..	134	1,9..
Egina .. ..	3	Egina Copper Mine .. ..	260	3,900	208	1,7..
Total .. ..	..	.. .. .	7,018	55,270	2,555	29,47..

*reported to the Mines Department to 30th April, 1907.*

1900.		1901.		1902 to 1906.		To 30th April, 1907.		Total.		Total of each District.	
Tons of Ore.	Value. £	Tons of Ore.	Value. £	Tons of Ore.	Value. £	Tons of Ore.	Value. £	Tons of Ore.	Value. £	Tons of Ore.	Value. £
26	468	..	..	..	..	..	..	159	2,459	484	8,806
..	..	22	287	..	..	..	..	22	287		
..	..	..	..	..	..	303	6,060	303	6,060		
1,198	6,493	86	598	..	..	..	..	2,009	12,036		
..	..	1,054	15,006	..	..	804	21,398	9,901	106,385		
..	..	..	..	..	..	..	..	20	150	11,940	118,671
..	..	..	..	..	..	..	..	10	100		
..	..	..	..	..	..	..	..	40	595		
319	4,230	..	..	..	..	..	..	453	5,593	493	6,188
62	948	..	..	..	..	..	..	530	6,571	530	6,571
1,805	12,139	1,162	15,891	..	..	1,107	27,458	..	..	13,447	140,236

*Weerianna Mines.*—These lie  $1\frac{1}{2}$  to 2 miles west of Roebourne, on the western side of the hills immediately west of the town. The hills at the foot of which the mining belt lies are a large outcrop of the ferruginous quartzite and dark jasper formation striking north-easterly, parallel with the principal course of the reefs. The quartz reefs, which are numerous, are found in a belt of country lying along the foot of the quartzite hills and nearly a quarter of a mile wide. About half a mile north-east from the old Herman's Reward workings there is a very large prominent outcrop of white quartz forming a conspicuous feature in the landscape, which seems to be probably part of the same reef, or group of reefs, as again outcrops boldly about a quarter of a mile west of the same old mine. These reefs do not seem to have been worked upon, so presumably no gold has been found yet in the quartz. They seem to form the western edge of the belt of reef-bearing country lying between them and the quartzite hills. In this belt outcrops of quartz are very common, and it is at present impossible to say how many reefs there are, the belt being more or less seamed with them. Their course seems to be generally about north-east and south-west.

*Herman's Reward.*—On this old lease, not occupied at the time of my visit, there are two old shafts which seem to be somewhere about 40 feet deep, and some open-cut workings, but it is not quite clear how many reefs were worked. The principal one seems to be that worked in a cutting on the outcrop, where a body of quartz is seen about 2 feet 6 inches to 3 feet wide, striking north-easterly and dipping somewhat flatly to the south-east. The quartz is stained with oxide of iron, and also at times with a little oxide and carbonate of copper. Having been informed that recently taken samples from the outcrop had yielded assay returns of about 25 dwts. gold per ton average I took a sample bagful of chips from the outcrop and the broken quartz lying beside it, which was assayed in Perth and gave:—Gold, 4 dwts. 9 grs. per ton; and silver, 6 dwts. 13 grs. per ton, showing that the place is worth further prospecting and testing. According to the Government Geologist's report of 29th August, 1906, it is recorded that in 1897 there were crushed from Herman's Reward 8.45 tons of ore for a return of 100.50 ozs. Three tons treated at Dry Creek, South Australia, are also stated to have returned 45.00 ounces of gold. The files of the *Northern Public Opinion* show 12 tons treated in 1897 for 142.60 ounces, these figures, though not exactly agreeing with the above, referring probably to the same returns. The information given to the Government Geologist over a year ago by Mr. Chas. Bull, who was then prospecting the locality, to the effect that "he had found several small patches of rich stone, but there appeared to be no permanence in the shoots," seems therefore to have been very probably a correct summing up of the state of affairs. The amount of work done, however, is not enough to demonstrate that the reefs are unpayable

altogether, and they seemed to me well worth testing in a more systematic manner to ascertain if they could not be worked as a proposition of somewhat low average grade, with chances of occasional rich bunches of ore.

*Welcome G.M.L. 75.*—In this old lease there are several shafts sunk on a large body of quartz, said to be of low grade. The reef is in soft schist country close to the foot of the quartzite hills. No work has been done on this of late years, and no crushing returns are recorded.

*Porterminna G.M.L. 135, and Porterminna Extended G.M.L. 136*—These leases have been taken up on parts of the old holdings of the "Eureka" G.M.L. 94, and "Golden Pile" G.M.L. 90, the workings being on the old shafts of these two former leases and on a new discovery about half-way between these. At the time of my visit the "Golden Pile" shaft had water in it, and nothing could be seen, though some work had been done recently. It was 90 feet deep with water up to 76 feet, the quantity of water having lately become too great for sinking to be continued by manual labour alone. The reef is about 2 feet thick, of white quartz, striking north 64 degrees east, and dipping vertically. The manager told me that assays of from 15 to 20 dwts. gold per ton could be got at 25 feet in the shaft across a width of two, to eight feet. According to Mr. Becher, Inspector of Mines, quoted in the Government Geologist's report of 29th August, 1906, the prospectors in 1896 had got coarse gold in the stone, and some beautiful specimens had been obtained. There is, however, no official record of their returns from ore crushed.

The "New Find" had been struck only a day or two before my visit, and all the work done on it was a hole about six feet deep, in which the size of the reef could not be distinctly seen. The stone is bluish quartz with stains of green carbonate of copper, and a few specks of galena, and some of it was very rich, though the gold was fine. I was told that some of this stuff assayed 41 ozs. to the ton, which was quite credible for such picked stone. I took a bag of fragments from the heap thrown out of the hole on the lode, which gave on assay:—Gold, 2 ozs. 17 dwt. 17 grs.; and silver, 18 dwts. 12 grs. per ton. The reef seems to be a fairly strong body of quartz, and is a very promising prospect.

The "Eureka" shaft is sunk vertically 45 feet and then goes 30 feet deeper on the underlay of the reef to the south-east. The reef runs north 67 degrees east, and underlays south-east about one in 10. There is a hard bar of bluish quartz, and on the sides of it the soft schist country carries numerous veins of quartz and is auriferous for some width. I was informed that a recent sampling

had given an assay value of over an ounce of gold per ton over a width of 10 feet. At the 45 feet level some crosscutting has been done, showing a width of over 20 feet of schistose lode matter, which I was informed was poor on the whole, but contained some rich veins. The lode seems to be a rather wide "formation" of schist and quartz leaders, and will require considerable opening up before much can be said about its value. The owners seemed very well satisfied with their prospects. Another little reef of bluish quartz is seen about 150 feet north of the "Eureka" shaft, in which assays are said to have been got of about seven dwts. gold per ton, and it seems probable that there are several parallel reefs in this part of the mineral belt.

I took a sample of the schist and quartz lying about the dump at the "Eureka" shaft, from several places and the assay return was:—Gold, 1 oz. 7 dwt. 5 grs. per ton; silver, 18 dwt. 12 grs. per ton, which shows that there is some very payable ore to be had. This property seems very well worth thorough prospecting, and seeing that there is a stretch of proved auriferous ground nearly a mile in length from the "Herman's Reward" to the "Eureka," and that the reefs are numerous, it seems to me that there is a very fair chance of an important discovery being made in this Weerianna belt.

The Government Geologist's report of 29th August, 1906, gives the yield of gold from the "Eureka":—

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
1897 ... ..	10·90	125·00	11·45
1900 ... ..	5·90	41·80	7·08
1905 ... ..	4·00	31·05	7·76
Total ...	20·80	197·85	9·51

There are no crushing plants at present available in the vicinity of Roebourne at which trial crushings could be made, the nearest being a small prospecting battery at Nichol Bay, some twelve miles distant from Weerianna. It will therefore be necessary for a battery to be obtained soon in order that the reefs may be satisfactorily tested.

#### LOWER NICHOL DISTRICT.

About 14 miles west of Roebourne at the head of the estuary of the Nichol River there are several gold-bearing reefs on which some work has been done, and there are considerable alluvial workings. The latter have been worked off



and on for a long time past, and two dryblowers still on them are stated to have made a living there almost continuously for several years. I was informed that several "slugs" of from five to ten ounces in weight had been got at various times. The ground is mostly shallow, but some of it in the flats along the estuary is stated to be about nine feet deep. There is said to be gold in the mud-flats of the estuary and some little time ago there was a proposition to work these deposits by dredging, but nothing has yet come of this. I cannot express any opinion upon the feasibility of this proposal on the little I could see of it in a flying visit. Systematic testing of the ground to be dredged is obviously necessary before a reliable opinion could be formed.

Near the head of the estuary there are several outcrops of reefs seen projecting from the mud-flats, and some are also seen a little farther inland, as far as the old King's mine. These reefs run fairly parallel to one another on a course of about north 70 degrees east with a slight tendency to converge towards the east end. They are in schist country, well laminated, which I think will prove to be diorite schist.

*The King's Gold Mines—Old G.M.L. 122.*—This reef runs north 70 degrees east, and dips south-east 40 degrees to 60 degrees. It has been traced by workings for some considerable distance, but these are not now accessible underground. The water level is about 20 feet below the surface. None of the workings seem to have been extensive. The reef shows 18 inches to two feet of quartz, lying parallel with the laminations of the schist. I take it to be a fissure lode and a fairly strong one. The quartz carries some copper minerals, and a little gold can be seen at times when examining the stone. One prospector does a little work on this reef from time to time, getting out stone from near the surface. The mine has not been worked seriously for several years. Its recorded output is shown below in the general table of returns from the West Pilbara Goldfield.

*Ninety-Nine G.M.L. 106, and Century G.M.L. 109.*—The Century reef is the furthest north of the group of parallel quartz reefs opened in this locality, and outcrops in the beach under the high-water mark of the estuary. Where the outcrop has not been cut away it stands out from the beach as a little wall of quartz up to two feet in height, but most of it has been taken out to depths of from five to 25 feet, the excavation forming a straight trench across the beach, at present full of water. The reef is remarkably regular in size, strike, and dip, realising the ideal appearance of a reef as shown in text-book diagrams. Its average width is about two feet. The quartz is stained a good deal with oxide of iron and at times with copper carbonates. Some very rich stone obtained from it

was shown me by Mr. Tozer, who has been working it. This came mostly from a shoot of ore towards the east end of the outcrop, where it leaves the beach and crosses a flat ridge running out into the mud-flats. A little further east the reef bends slightly and seems to divide into two or more branches. It is said, however, to be visible again across Nichol Creek, on the east side of the estuary. North of this reef there is an outcrop of hardened and silicified schist which forms a bar across the beach, and Mr. Tozer informed me that he had never known the tidal waters to come past this bar. The workings were full of water at the time of my visit, but he said that water was not troublesome when the mine was in operation, the country schist being apparently fairly impervious to water. There does not seem, therefore, to be much reason to fear that the reef will not be workable on account of its being on the sea beach, although it will clearly be necessary to take precautions to prevent an influx of water in the event of an abnormally high tide. The beach is so flat that a protective bank of earth need only be a very low one. Mr. Tozer has a 3-head prospecting battery of 250 lb. stamps near his mine, and informed me that he had crushed 100 tons of ore with it from this mine with an average return of about 3oz. per ton, tailings assaying 12 to 15dwts. per ton. About four years ago Mr. J. W. Archibald worked this reef, and also took the outcrop stone from several parallel reefs lying between it and the Kings reef, crushing the stone with a 10-head battery, since removed, the boiler of which is still on the ground. He has informed me that he crushed about 800 tons from the reef for an average return of 4dwts. of fine gold to the ton, and that there were  $2\frac{1}{2}$ dwts. per ton fine gold in the tailings. He also crushed about 50 tons of schist from near the reef.

The group of reefs at the Lower Nichol seemed to me well worth further attention from prospectors, the trial that has been already given to it being by no means conclusive. The reefs are distinct and strong, and the Century and Kings reefs have been proved to carry gold for fairly long distances along their outcrops. The country rock is easily workable, and access either by land from Roebourne or by sea from Nichol Bay is not difficult. Supplies of mining timber and firewood are not good, but are better than in most of the Pilbara fields, there being a good deal of timber in the valley of the Nichol river within reasonable distance for carting.

The recorded returns from the Lower Nichol district are shown in the following General Table of Gold Production of the West Pilbara Goldfield.





*Iron Deposits.*—About 6 miles from Roebourne, on the road to the Lower Nichol, the road passes a great outcrop of dark oxide of iron, which seems to run north-north-easterly. I did not examine this when driving out to the Nichol, but from the cursory glance obtained in passing there seems to be a very large deposit in the form of a lode, which might be very useful as flux for the copper smelters.

*Other Discoveries.*—While at Roebourne I heard of several prospectors having found gold at various points in the surrounding district, and there seems little doubt that several mines will be opened up if the prospectors are well supported by the investing public. The country is favourable for minerals, and much more easily accessible and cheaply workable than the inland fields.

*Clarke's Antimony and Gold Mines.*—Owing to receiving information that work had been abandoned, and the application for leases withdrawn, I did not attempt to visit this mine which has since caused me much regret, as it turned out that the information was to some extent due to a misunderstanding. Mr. Clarke saw me in Roebourne, when there was no longer time to go out to the mine before the arrival of the steamer by which I had to return to Perth, and told me that he had been working the mine till a few days before and intended to continue work as soon as a difficulty could be settled between himself and the directors in Adelaide of the Clarke's Antimony-Gold Syndicate, N.L. He exhibited some very fine specimens of quartz, carrying sulphide of antimony through it, and very rich in gold, and of very pure solid stibnite (sulphide of antimony) and cervantite (oxide of antimony), and informed me that the lode has been traced through two blocks of 40 acres each taken up upon it, and was as much as 12 feet wide at surface. Very solid and pure stibnite is said by him to be readily obtainable in good quantity, and the rich gold ore occurs in a short shoot in a good-sized reef which is of fair value outside the shoot. Two shafts have been sunk, one 25 feet deep, the other 40 feet. The mine is near the crossing of the Sherlock River, on the road from Roebourne to Croydon, about 39 miles from Roebourne and 16 miles from Croydon Station. It is about 24 miles from Balla Balla, and eight miles from Sherlock Station. I cannot vouch for the information obtained from Mr. Clarke, but he has without doubt some excellent stibnite and some rich gold-bearing ore, specimens of both from his mine having been shown to me at Station Peak and Croydon by others, as well as by himself at Roebourne. The discovery seems to be well thought of by local residents who are in a position to know the truth about it.

*Fuchsite Rock.*—A piece of very green coloured rock was given to me at Roebourne by Mr. A. G. Holroyd, found in the vicinity of the Sherlock Station, which is worth noting on account of its

very close resemblance to rock coloured with green carbonate of copper, being thereby very liable to mislead prospectors. It contains neither copper nor nickel, the two metals usually responsible for bright green colouring of ores. The Government Mineralogist and Assayer examined it, and reports it to be a "Fuchsite-rock, composed almost wholly of minute scales of chrome-mica (fuchsite)," which is of a bright green colour. It is of no value, the quantity of chromium in it being too small to allow of its use for production of chrome compounds.

#### WHIM CREEK DISTRICT.

The principal mine in the Whim Creek district is that of the Whim Well Copper Mines, Ltd., on North Location 71, which lies about 13 miles south of the jetty at Balla Balla, and eastward from Roebourne some 50 miles by road. There are also workings at Mt. Negri, about four miles north from the Whim Well mine, and rather less than three miles south-south-westerly from the latter lie those of the Mons Cupri mines. At the time of my visit work was confined to the Whim Well Company's mine and two adjacent leases.

The Geological Survey of the West Pilbara Goldfield has not yet been completed in the Whim Creek district, and my flying examination of the country in this neighbourhood was much too brief to enable me to say with any certainty to which of the formations previously mentioned in the Geological sketch the principal rocks of the locality should be referred. Those of the Whim Well mine and its immediate vicinity are mostly laminated slates and schists, varying very much in strike and dip, but generally dipping northerly at somewhat flat angles. The strike varies in short distances from north and south to east and west, and the dip from easterly to northerly. On the whole the slate appears to be a somewhat flat-lying series of strata very much crumpled. At the Mons Cupri the mine workings are mostly in indistinctly bedded rocks composed of fragmentary argillaceous and arenaceous material with frequent enclosures of rounded subangular pieces of older rocks. These strata are of somewhat tufaceous nature, but I was unable to satisfy myself whether they were purely sedimentary debris of felspathic rocks, or truly volcanic tuffs and agglomerates. The strike is not clearly seen, but appears to be more or less north-west and south-east, with slight dip to the south-west. Near the mouth of the lowest tunnel, on the southern side of the hill, there is an igneous felspathic rock which may be a dyke, and a somewhat similar one is seen at the water shaft. The rocks at Mons Cupri are much weathered, and it is therefore somewhat difficult to determine their true classification without more extended examination than I had time to give them. From the fact of the strata throughout the district having generally low angles of dip and apparently forming portions of a much crumpled but on the whole rather flat-lying



series, they seem more likely to belong to the "Nullagine Beds" of the Geological Survey than to any other formation yet recognised in the Pilbara Fields. In support of this it may be mentioned that the road from Mallina to Whim Creek passes over hills on which vesicular lavas are largely developed, quite similar to those characteristic of the Nullagine formation in its typical occurrences near Marble Bar and Nullagine. Igneous rocks very like these are also seen on the road between Whim Creek and Mons Cupri, but I did not notice any showing the characteristic vesicular structure.

Unusual economic interest attaches to the geological structure of this district on account of the principal ore-body yet discovered, the Whim Well lode, being possibly a truly bedded deposit. It lies very nearly if not quite in the bedding of the enclosing slates, and appears to have been in existence when they were subjected to crumpling through movements of the earth's crust, as it partakes—so far as yet seen—of the same bends and twists as the enclosing slate. It may prove on further opening up to be a fissure lode closely following the bedding of the slate where seen at present, but possibly crossing it in depth, or it may be that it is similar in formation to the celebrated copper-bearing schists of Mansfield, in Saxony, where there is a truly bedded stratum of cupriferous material extending over an enormous area. At one time it was generally considered that the copper ores of the Mansfield schist were laid down simultaneously with the sediments enclosing them, but more modern authorities mostly regard them as subsequently introduced, holding that they have been precipitated in the layer of "copper-schist" from solutions traversing the country on account of the schist having been in some way either more permeable than the strata above and below it, or containing constituents which caused special precipitation of the ores. The occurrence of the copper ores in the "copper-schist" is thus similar to that of gold in the "banket" reefs of South Africa, and the conglomerate at Nullagine, in both of which cases gold has been deposited by secondary processes in the interstices between the pebbles of a conglomerate. The ore deposits, however, in all these cases are closely confined to the favourable stratum, and for mining purposes this may be regarded as a bedded deposit. As seen at present there seems to me to be a very considerable possibility that the Whim Well "lode" is such a deposit, and if so it may be of much industrial importance to determine the position of the cupriferous layer elsewhere in the district by careful correlation and mapping of the enclosing strata. Should further exploration, however, prove it to be a fissure lode, and that its apparently bedded nature is merely due to a fortuitous coincidence, no special importance would attach to its position in the series of sedimentary strata.

Mr. E. J. Dunn, F.G.S., when reporting on the Whim Well mine, on 8th January. 1898, noted the conformity of the lode with

the bedded planes of the country slate, but was of opinion that "the lode consists of a very compact felsite rock of igneous origin," containing veins, branches, and masses of copper oxide, carbonate, etc. Mr. C. E. Gibson, Assistant Government Geologist, in his report of 12th March, 1906, also considers that the mass of the lode is of igneous origin, regarding it as a dyke of "what appears to be a decomposed serpentine (?) " which "has undergone considerable alteration down to water-level, and appears as a soft light-coloured aluminous rock, which near the surface is highly impregnated—principally on the hanging wall side—with copper, which occurs as veins and masses of blue and green carbonates." My own observations did not induce me to adopt the view that the lode was originally an igneous rock, whether regarded as an intrusive dyke or sill, or an interbedded lava sheet, though in places there were occurrences of indurated aluminous material that strongly suggested an altered felsite, as I saw nothing in the lode stuff which seemed to me indubitably of igneous origin, and which could not equally well be accounted for by alteration of a bed of the "country" by the action of lode-forming agencies and subsequent superficial weathering. In the largest and richest parts of the lode yet worked the copper ores have been usually found in a gangue largely composed of kaolin, and while this could be formed by decomposition of a felsite it could equally well result from hydrothermal or pneumatolytic action upon aluminous slates, or even from the chemical reactions which commonly take place in the portions of lodes above the water-level owing to oxidation of sulphides and access of downward percolating surface water. The whole of the mine workings are as yet in the zone of oxidation above the permanent water-level, and in consequence we find the usual features of copper lodes under such conditions, viz., gossans nearly free from copper at surface, and beneath them weathered lode matter much stained with carbonates and oxides of copper and iron oxide, and containing rich secondary aggregates of oxidised copper ores in veins, bunches, and impregnations, followed, a little lower down, by rich secondary sulphides. In all this part of the lode there has been strong chemical action owing to the oxidation of the original pyritic constituents, soluble constituents being largely removed both from the lode-slate and the wall rock, leaving a residue of kaolin. Deposition of silica as quartz and chert is also a common result of the weathering reactions. I saw nothing in the Whim Well lode that did not seem easily explainable on this basis without supposing that there had been any igneous dyke, and in the deepest workings the lode gangue seemed to me to be very similar to the enclosing country slates without any appearance of turning into felsite or other dyke rock.

*Whim Well Copper Mines, Ltd.*—This Company was formed in July, 1906, with a capital of £25,000 in 25,000 ordinary shares

of £1 each, which was, in December of the same year, increased to £150,000. The Company owns location 71 of 100 acres as a freehold, and has also applied for several mineral leaseholds under the Mining Act, 1904. The freehold is on a range of small hills, the ridge of which runs roughly east and west a short distance to the north of the south boundary of the holding. The outcrop of the lode is traceable through nearly the whole length of the freehold (50 chains), and is seen again in the ground held by the Whim Well East Copper Co., which adjoins its north-east angle. The dip is somewhat flat, and often nearly the same as the slope of the hills to the northward, consequently in many places there is very little country rock covering the lode, and it is seen lying bare on the surface of the hill. In some of the gullies it has been partially removed by denudation, and on the ridges it is under considerable cover. Owing to the flat dip of the lode and the slopes of the hill therefore, the outcrop is very sinuous. As already mentioned, the lode itself is crumpled conformably with the enclosing slates, and therefore varies a good deal in both strike and dip. The top of the hill where the lode crops out has been cut about in every direction by open cuts, trenches, and shallow shafts, while lower down several small tunnels have been put in, from which ore has been stoped out. There are also several old tunnels, put in before the present Company acquired the property, which go away into the footwall country of the lode, and which were from the first plainly useless for working it, but may have been thought judicious for prospecting purposes. In one of these, under the western surface workings, there are strings of ore through weathered country rock, and a winze has been sunk some distance on a vein of ore dipping oppositely to the main lode. The ore at this point, however, seemed to me to be more likely due to downward percolation of copper-bearing solutions from the lode above during its decomposition through weathering than to original veins, though the vein in the winze may perhaps be of more permanent character.

At several points on the outcrop there are occurrences of brown and black oxides of iron and manganese, often somewhat siliceous, of cylinder-like texture, which probably represent the oxidised remains of original bodies of pyrites in the lode. One of the largest of these is nearly over the "ball-room," a large underground excavation from which most of the 1,054 tons of first-class ore shipped in 1901 were obtained. The ore in this excavation was mostly "liver" or "tile" ore, a mixture of oxides of copper and iron, with a considerable amount of green carbonate of copper. Some copper glance and black oxide of copper were also obtained. The ore was of secondary nature, evidently a chemical concentration, and was doubtless formed by precipitation from cupriferous solutions from higher parts of the lode. In the main workings of the present Company there is a large mass of rich ore of similar forma-

tion, rich oxides, carbonates, and glance (sulphide) ore being distributed through a kaolin and brown iron ore gangue.

As the slope of the hills flattens out towards the plain the lode dips deeper under the surface, and two shafts have been sunk to a depth of about 80 feet to cut it. In the more easterly one the water level is at about 78 feet, and a crosscut has been put in at 70 feet some 15 feet or so to the hanging wall of the lode. The crosscut then goes on for 24 feet before cutting the footwall, showing the lode to be about six feet thick measured at right angles to the walls. This lode-stuff contains some very good glance ore, and is said to have averaged six to 10 per cent of copper when being excavated. A drive has also been made westward along the lode to connect with the other shaft. The bedding of the country at this place runs about north-west and south-east, and the dip is to the north-east, the lode conforming with the stratification. The lode-stuff is still much weathered, and the copper ores are still concentrated secondary products. Probably pyritic ores will be met with before going much deeper. The lode is "living" very satisfactorily at the depth at which it is seen in the shafts, and the material composing it seemed to me to be more of the nature of the filling of a fissure than of a bedded deposit. There is a very large area of ore-bearing stuff now proved between the 70-foot level and the top of the hills, and extension of the level along the course of the lode will rapidly increase the reserves of ore which may be regarded as "in sight."

The deeper development of the mine below water-level will require shafts still further to the north than the above, but before settling on sinking these I would strongly advocate testing the deposit in depth by diamond drill boring. The flat dip makes this method of trial particularly serviceable, and numerous holes could rapidly be run down to cut the lode so as to prove its position and give some information as to its value, and would serve to enable the main shaft to be located to the best advantage. It is important to open the lode below the water-level, not only for the purpose of exploring the mine and increasing the ore reserves, but also to provide sulphide ores with which to smelt the lower-grade oxidised material from the shallow workings, of which there is a very large quantity available.

The thickness of the lode is very variable in the various workings, being over 30 feet in some of the big kaolin bodies, and going down in other places to about two feet, or even less. In the oxidised zone there has been so much precipitation of ore in the wall rock that it is often hard to say how much of the stained cupriferous matter should be regarded commercially as part of the lode, and the width worked will depend on the extent to which the values are payable. Taking the exposures all through, the lode would probably average fully six feet in thickness.

The yield of ore from this mine has been very good, the official returns being :—

Year.	Tons of Ore.	Value.
		£
Previous to 1899 ...	6,638	49,785
1899 ...	1,405	20,196
1900 ...	Nil	Nil
1901 ...	1,054	15,006
1902 to 1906	Nil	Nil
To end of May, 1907 ...	976	25,340
Total ...	10,073	110,327

The present company have up to the end of May shipped about 1,100 tons of ore averaging 26 per cent. of copper (not yet all included in the above return) and almost the same amount shipped in 1901 had the same average copper contents. The ore previously shipped is said to have yielded from 22 to 40 per cent. of copper. When Mr. E. J. Dunn reported on the mine in January, 1898, he sampled 17 dumps and ore-heaps, mostly second-class stuff, containing 3,600 tons of ore and obtained an average assay value of 11.16 per cent. copper, but he points out that 800 tons of 22 per cent. ore had been picked out of this and shipped as well, giving an average for 4,400 tons of 15 per cent. copper. My visit was much too short to permit of sampling or of making any measurements of the dumps now on the mine, but the manager's rough estimate of 10,000 to 12,000 tons of second-class ore on the various dumps, of assay from 8 per cent. to 10 per cent. copper, seemed very reasonable. The amount of ore in unbroken faces was very much larger, and according to the manager's sampling and assays many of these gave bulk values of from 10 to 15 per cent. of copper. In 1898 Mr. E. J. Dunn estimated the ore available from short adits and open-cut workings at 130,000 tons, and a more recent report, dated November, 1906, by Mr. R. Schloesser, estimates 200,000 tons as available above water-level. In the present state of the mine such calculations can only be taken as attempts to approximate in figures to the quantity which on present knowledge seems likely to be obtained, and taken with this reservation they do not appear to me to be in any way unreasonable. The quantity of ore that there is every reason to expect can be got is plainly very large.

At present the first-class ore is picked by hand and bagged for shipment to Europe and to facilitate this process the Company are about to erect ore-bins and machinery for better handling and dressing. This plant will greatly reduce the cost of hand-dressing the ore, but is not a concentrating plant in the ordinary sense of one in which the ore is separated from the gangue by means of

water or a pneumatic treatment. The rejected material will still contain a very appreciable amount of copper.

According to figures given to me by the manager, Mr. Sleeman, the total costs of mining, shipping, and realising ore containing 25 per cent. copper, including smelters' deductions from the assay value, under present conditions have worked out at about £10 12s. 2d. a ton equal to 10.61 units of copper when the metal is worth £100 per ton (or 20s. per unit). Of these charges bags, bagging, and loading amount to 17s. a ton, cartage to the coast, lighterage, wharfage, and agency, 30s. a ton, and ocean freight and insurance 37s. a ton, the total of these items being £4 4s. per ton. By having a tramway to the coast and making arrangements to ship the ore in bulk by sailing vessel there is much hope that it would be possible to cut down expenses between the mine and the European smelter to from 27s. to 30s., or say £2 15s. less than at present. The dressing plant will probably reduce present costs of dressing quite 4s. a ton, but it is unlikely that mining, administration, smelting and realisation charges would be greatly different from those now prevailing. Probably the costs might be reduced by an amount of about £3 a ton in all, to say £7 12s., equal, with copper at the same price as above, to 7.60 units. This, however, would represent the lowest grade of ore that would cover expenses, even at the present good price of copper, and would necessitate very excellent arrangements for shipping the ore. Should copper fall to 15s. per unit (£75 per ton), it would require nearly 10 per cent. of copper in the ore to pay the expenses. But ore of from  $7\frac{1}{2}$  to 10 per cent. copper should be capable of being smelted locally at a good profit, so it seems to be indicated that local smelting is desirable. As above noted there is a large amount of ore of about this grade already broken out on the dumps and much more in sight, and though doubtless this could be picked over and dressed so as to yield a shipping grade of say 12 to 15 per cent. and seconds of less than 5 per cent., it seems to me, without having gone fully into the matter, that local smelting *en masse* would be likely to be the more profitable policy. The question, however, is one for very close calculation of relative costs and profits by those immediately interested, and it may be that they might find it would suit them best to pick and ship for a time. Whether local smelting or foreign shipment is chosen, there will be in either case a large amount of low-grade oxide and carbonate ore rejected from the superficial workings of the mine, and the question of treatment of this by a lixiviation process will deserve very serious attention.

The Company have already decided to construct a tramway, or light railway, from the mine to Balla Balla, and this work is to be gone on with very shortly. The distance is stated to be 13.6 miles. This will be an immense help to the opening up of the mine and of the district behind it.



They have also considered the question of smelting works, and, I understand, have picked upon a site near Coorinjinna Pool at the mouth of the Balla Balla Creek about three miles from the Balla Balla jetty. In this pool there is a good supply of fresh water, said to be never known to dry up, and usually overflowing into the estuary of the creek. The water issues from below a sheet 4 to 10 feet thick of impure limestone of recent age, which here overlies the older slates and schists and extends over a wide area of the coastal plain. Probably the same flow of water could be got in wells nearer the coast, close to the Balla Balla townsite, and in view of the fact that the Coorinjinna Pool is required for stock and is of very great service to the pastoralists travelling sheep and cattle along the coastal stock route—on which it is situated—it would be best to try to obtain a supply for the smelter from wells rather than from the Pool and to keep the works some distance from it, though water could be taken by pipes from it if necessary. A supply of salt water for the water-jackets of blast furnaces can be obtained from the estuary at all times.

Some of the limestone above mentioned is pure enough for smelting use as flux and could be very cheaply obtained at the proposed smelting works site. There is a certain amount of fair oxide of iron flux carrying some copper in the Whim Well Mine itself in the oxidised zone, and I was informed that large quantities of iron ore of good fluxing quality were obtainable in the neighbourhood at low cost. Coke and coal can be landed at Balla Balla fairly cheaply and when the tramway is built the conditions for local smelting should be on the whole very favourable. At present the Whim Well Mine does not produce sufficient sulphide ore for matte smelting, but this will probably be remedied when the lower levels are opened up, and a certain amount of sulphide ore can also be obtained by sea from the mines round Roebourne. Smelting for black copper might have to be carried on for a time until more sulphides are available.

Should the deeper workings of the mine provide a sufficient supply of water for smelting purposes, as well as for concentrating the low-grade sulphides to be expected in depth, or if a good well were obtained near the mine, it seems to me that further consideration might well be given to the question of putting the smelting works on or near the mine, so that the lowest possible grade of ore might be treated with a minimum of handling. With the smelter near the mine the work of the tramway would be much less than if all the ore had to go over it, and there would be a better balance of loading, the matte and copper going down going far to balance the coke and supplies going up, giving approximate equality of loading both ways, a condition favourable for cheap running costs on the tramway. Concentration of all work under the manager's immediate supervision is also an advantage not to be lost sight of.

On the other hand if the Company contemplated buying ores from the Roebourne, Ashburton, and Derby fields could readily be brought to Balla Balla, the smelting on the coast would clearly have advantages. None of these fields could develop extensively without requiring local smelters of their own, and supplies from them would therefore only be obtainable for no long period.

*The Whim Well East Copper Company, No-Liability* 66 and 80.—To the north-east of the Whim Well Company's main block are two mineral leases of 15 and 24 acres held by the Whim Well East Company, on which work was in progress at the time of my visit. The Whim Well lode is traced close to the western boundary of this property, and the lode found in the latter is really a continuation of it. As seen at the Company's main shaft it is running nearly north-south, the enclosing slate country conforming with it in dip. In some workings a little further east however the lode and slates are seen to turn to a nearly east and west dip. There may be a fault in the lode between where it is on the property and the last outcrop to the east on the Whim Well Company's block; if not there seems to be an exceedingly sudden bend in the lode and enclosing strata. The main shaft has been sunk to the bottom and at the time of my visit crosscutting was in progress at the bottom of it to cut the lode. This has been opened at the bottom and worked downwards on the underlay, passing through to the lode at a depth of about 35 feet from surface. The lode stuff is a soft ore, wide, composed of iron oxide and kaolin with oxides and silicates of copper. The manager told me that 20 tons of ore had been shipped, which returned 10½ per cent. copper, 9ozs. silver, and 2½dwts. gold per ton. He had about 3 tons of ore on hand bagged on the mine and 3 tons at Balla Balla waiting for shipment. Cartage to Balla Balla cost 20s., loading 2s., lighterage 2s., and freight to Fremantle 20s. He was using 25 tons, costing 4s. 6d. per dozen.

The outcrop has not been traced very far in this direction, but the lode seems well worth opening up, and by driving a crosscut soon be seen whether it is extending in that direction.

*Bond's Reward, M.L. 74.*—This lies to the west of the Whim Well Company's shafts above-mentioned. A shaft was sunk at the time of my visit, which was then down fifty feet into the country, dipping sharply to the E.N.E. A little further the dip is quite to the east or even a little south of east. In this the Whim Well lode continues to conform with the stratification of the country, there is a strong probability that at this point the lode is entirely in the footwall country, below the lode. The workings are proceeding on the theory that the lode is a fissure vein and will keep its course westward as last seen in the Whim Well.

irrespective of the enclosing strata. It is to be said in favour of this theory that no sign has been seen of the lode outcropping at surface between this shaft and those of the Whim Well mine, as it would if it had bent round sharply conformably with the strata, and in view of the reasonable doubt possible as to the nature of the deposit the enterprise of the owners of this ground in sinking to ascertain the facts by the only satisfactory method—that of actual mining work—is entirely commendable.

*Mons Cupri, M.L. 34.*—This mine was formerly worked by the Balla Balla Copper Mines Company, but has lately been acquired by the Whim Well Copper Mines, Ltd. It is situated on a rounded dome-like hill rising to a height of perhaps 300ft. above the surrounding flat country. The top of the hill is covered with impure brown iron ore, apparently mostly formed by oxidation and alteration by weathering of the underlying rocks. These as previously mentioned are felspathic conglomerates and tufaceous sandstones. The rocks outcropping on the surface just below the ironstone capping of the hill are very much stained and veined with green and blue carbonates of copper, silicate of copper, and oxides of copper and iron, the cupriferous staining being very extensive. When first found it must have offered a most attractive prospect fully justifying the name of Mons Cupri (Hill of Copper) given to it. The copper-bearing material has been cut into nearly all round the hill by series of open cuts and quarries, a large amount of work having been done. There are also two fairly long tunnels from opposite sides of the hill and in one of these a vein traced from the surface workings has been followed downwards by a winze. In the cuts and quarries there is at first sight a very attractive show of copper, green and blue colours appearing on every side, but closer examination soon shows that most of these are due to thin deposits of copper minerals in the joints of the country. Larger veins are not uncommon, however, from which fairly good carbonate and "liver" ore can be picked, but on the whole the mass of cupriferous rock is very poor and highly silicious. I saw no place where there was any definite lode visible, with the doubtful exception of one vein worked downwards by a winze from the open workings on the south side of the hill, and in the winze below the low level tunnel. Even this vein however might well be due to the cupriferous solutions which have stained the higher country finding their way downwards along a fracture somewhat larger and more regular than the small ones in which most of the little veins have been formed. In the low-level tunnel the country rock contained much pyrites, and efflorescences of copper sulphate on the walls showed that even now the metal is travelling through the rock in a state of solution, but I hardly think that the pyrites themselves are sufficiently cupriferous to have been the source of the copper deposits above. It may be that these are due to repeated concentration by superficial agencies of the copper present in small quantities

in the pyrites, but I hardly think that this can be so. It is more likely that the copper has come from a bedded one time overlying the present surface of the hill and has been removed by denudation, and that the present ores are derived from it by dissolved copper percolating downwards into the lying country.

In some of the cuts there are portions of the rock with a considerable amount of copper, occasional bunches of carbonate and "liver" ore being obtainable, and the ore-dumps at these workings show a good deal of stuff which would probably be payable if smelted locally on a fairly large scale. I was surprised, however, that the samplings of these dumps had been unprofitable, the assays showing values much less than could be expected from the appearance of the ore. The production of this mine is shown by the foregoing table of copper production of the West Pilbara Goldfield to have been 2,009 tons of ore valued at £12,036.

There is a small round American water-jacket smelter on this mine, but it was run for only a very short time. The slag-dump shows that very little ore could have been smelted. Pyrites imported from Spain was used to supply the sulphur required for the matte.

This mine is on the whole of low-grade, but there is a large total quantity of copper in it, and it does not seem to be in any way a hopeless proposition. The richer veins are in places fairly plentiful, and there are chances of improvement in this respect as work proceeds. Much work can be done by open quarrying without underground mining, and there is hope that a more definite lode of ore body may be discovered. If a cheap lixiviation treatment of the low-grade oxide and carbonate ores could be instituted there would be a very large amount of payable ore readily available. Experiments in this direction are the most hopeful line of action, for if the bulk of the rock could be made to cover costs of mining and treatment, the richer veins and bunches obtained in breaking it would give a good profit. Valuable information as to the extent of the deposit could most rapidly be obtained by systematic boring with a diamond drill, but a considerable number of bores would be required.

#### MALLINA DISTRICT.

The Mallina Station homestead lies about 10 miles east south-east from Whim Creek on the road to the Peak, and the old mines are quite close to the homestead, the old mining shafts being now the Station well. A large amount of work was done here about 12 years ago by Calvert's Exploration, about which very little information is now obtainable. The country is highly plicated schist and sandstone very possibly belonging to the Mosquito Creek beds of the Geological Survey, and the mines are in flat ground. Work has lately been resumed on the

most of a series of parallel quartz reefs, on which were the most extensive of the old workings. These extend along the outcrop of the reef for over 1,200 feet, in a series of costeans and shafts of shallow depth. The course of the lode is about N. 80 degrees W. with underlay about 1 in 5 to the north. Near the east end of the workings there were several large shafts, on one of which there appears to have been winding machinery, and it is said there was also a 5 stamp battery. The workings are not now accessible, but the reef seems to have been a fairly strong one in this part, there being much quartz lying about the dumps—some of it contains a good deal of stibnite. To see if this antimonial ore carried gold I took a sample of it from one of the paddocks, but the assay result was very poor, viz.:—Antimony 5.06 per cent., gold *nil*, silver 1dwt. 20grs. per ton.

At the time of my visit work was proceeding at two of the old prospecting shafts close together near the centre of the outcrop, the western one of which had been equipped with a whip and the eastern with a windlass. Bailing was proceeding vigorously to unwater the shafts and drives therefrom, which are said to be some 400 feet in length. The shafts are 45 feet deep. Unfortunately the water was not got out till two days later, and I could not see the lode in the drives. At the outcrop the lode is seen to be a large reef of quartz 6 to 8 feet wide with well defined walls. The old dumps contain some very fine looking dense solid stibnite (sulphide of antimony) often heavily coated with cervantite (oxide of antimony), and these have recently been partially picked over to obtain antimony ore for shipment. One small parcel was shipped in March, 1907, for sale in England, and by the courtesy of the owners I have been enabled to obtain the following particulars from the account sales.

The parcel consisted of 205 bags, weighing gross 7 tons 2 cwt. 3 qrs. 26 lb., equal to a net dry weight of 6 tons 19 cwt. 2 qrs. 23 lbs. (6.9853 tons). The assay was 36.20 per cent. of metallic antimony. The ore was sold at a market rate (April 1907) of £24 per ton for 50 per cent. ore less 15s. per unit of metal less than 50 per cent., or equal to £13 13s. per ton, but subject to a further discount of  $2\frac{1}{2}$  per cent., which reduced the value realised to £13 6s. 2d. per ton, giving a value for the parcel of £92 19s. 4d. Shipping freight, dock and loading charges, and marine and fire insurance amounted to £14 5s. 10d., equal to £2 0s. 11d. per ton, assays and sampling to £2 17s., or 8s. 2d. per ton, and cablegrams and commission to £4 19s. 2d., or 14s. 2d. per ton, being a total of £22 2s. for these charges, equal to £3 3s. 3d. per ton. The net value realised was therefore £70 17s. 4d., or £10 2s. 11d. per ton. Against this return have, however, to be charged all expenses in this State of picking the ore, bagging it, and forwarding from the mine to Fremantle. No allowance seems to have been made by the smelters for the small amount of gold in the ore.

There was a heap of several tons of picked ore lying on the ground, from which I took a rough grab sample. It contained 44.96 per cent. antimony, gold 4dwt. 6grs. per ton, and silver 21grs. per ton. The return of antimony was lower than the appearance of the ore would lead one to expect, but the Chemist, Mineralogist and Assayer found on close examination that there was a lot of silica through the masses of stibnite.

It is said that along the drives, which I could not see, there is a large amount of stibnite visible, and that good shipping ore is freely obtainable. The appearance of the old dump seems to confirm this, there being a very considerable amount of antimony in it. Probably, as usual with this mineral, it will be found in richer lenses and bunches of greater or less size from which shipping ore can be hand picked, and also scattered throughout the dump in such a way as to require concentration to obtain a marketable product. The prospects seem to justify opening this mine with a view to testing if it is worth working for antimony. It does not seem to have been regarded as worth picking out when the mine was first worked. The market value of antimony has, however, lately dropped to less than half what it was when the mentioned parcel was sold.

Near the windlass shaft there was an old paddock with little antimony in it, which had evidently been put to some purpose. I took a sample of this, hoping to get gold, but on assay it only returned—gold 13grs. per ton, silver 1dwt. per ton. From the extent of the old workings it seems probable that the prospects of gold at first obtained were not enough to induce the owners to persevere for a considerable time with their trial of the mine, but there is no appearance of a large quantity of stone having been crushed. It is unfortunate that the record of the old tests has been so completely lost, and now when the mine is being tried again one of the first things to be done is to make a systematic sampling of all accessible parts of the reef for antimony and gold.

*The Mining Handbook of W.A.* (2nd edition 1895, p. 10) mentions that at Mallina "the gold is associated with sulphide of antimony, and in parts it is very rich, but the portion of the reef which carries much gold is small, although the reef itself is of considerable extent." This emphasises the necessity for very careful sampling of the auriferous parts of the reef.

Some 10 to 15 chains south of this lode close to the homestead the outcrops of three or perhaps four parallel reefs are visible, close to one another. One is a large white outcrop dipping northerly, in the foot wall of which a shaft has been sunk which is now used as the station well. This is a big lode, but little work has been done on it, so presumably it has been considered to be poor. About 70 feet north there is a parallel reef



6in. wide of quartz much iron-stained, on which there are some old shallow workings. South of the well some work has also been done on what seems like a branch from the big reef. I noticed a little antimony in some of the quartz in this. About 200 feet further south is the Stray Shot reef, which however dips somewhat flatly to the southward, its underlay being opposite to that of the other reefs of the series. This reef was small but a good deal of work was done on it, and I was informed that the last crushing from it returned over an ounce of gold to the ton, also that rich specimens from it were sent to the Paris Exhibition. To learn anything now about the value of these reefs it would be necessary to clean out the old workings and thoroughly sample the stone.

Such gold returns from Mallina as have been officially recorded are shown in the foregoing General Table of Gold Production of the West Pilbara Goldfield, but are probably very incomplete. They show 103.60 tons crushed for 102.83 ounces of fine gold.

Mallina is of historical interest as being the locality where gold was first found in the Pilbara fields in 1888 by Mr. James Withnell.

#### TOWRANNA DISTRICT.

The Towranna centre lies about twelve miles southwest of Mallina in dioritic schist country, and has been entirely deserted for some three or four years past. The Government Geologist's report of 16th November, 1906, gives some information about the old mines compiled from the reports of the Inspectors of Mines, from which the following particulars are taken:—

A very noticeable feature of the place is the occurrence of a belt of porphyry running nearly north and south in which the reefs appear to have been more persistent and richer than those found in the schists. Very little alluvial gold was found.

*Yellow Aster, G.M.L. 207.*—This was the principal mine of the district, and had some £13,000 spent on it in development work and in the erection of a 10-head battery and winding and pumping plant. There were some eight shafts sunk, one to about the 100 feet level, and considerable driving done. The reefs ran N.N.W. with easterly underlay, and were 18in. to 30in. thick, traversing the porphyry. From 1897 to 1899 there were crushed 1,000 tons of ore for 875.07ozs. of gold, and a subsequent small crushing in 1901 of 35 tons for 47.69ozs. and cyaniding of the tailings which yielded 231.98ozs., brought the total returns to the end of 1903 to 1,035 tons for 1,154.72ozs.

*Towranna Queen, G.M.L. 271.*—The workings on this lease were on a very flat vein 12 inches wide; 31 tons were crushed for 22.57ozs. of gold.

*Towranna, G.M.L. 204.*—The reef is said to have been 18 inches thick. Crushings are recorded from 1897 to 1900, a total of 848.80 tons returning 895.79ozs. of gold.

*Day Dawn, G.M.L. 87.*—Reef small—20 tons in 18 return of 15.18ozs. of gold.

*Diamond Jubilee, G.M.L. 101.*—11.00 tons returned gold.

The total officially recorded production of the Towranna is 1,934.80 tons crushed for 2,088.26 fine ounces of gold. Other mines were worked besides those mentioned, but no recorded crushings.

#### EGINA DISTRICT.

I did not visit this old centre, which is said in the *Mining Handbook of W.A.*, Second Edition, 1895. to have had a "rich patch of alluvial workings," the output of which does not appear to have been officially recorded separately. The Egina Copper Mine is, however, shown to have yielded 3,000 tons of copper ore valued at £6,571.

#### CROYDON DISTRICT.

Between Towranna and Croydon Station the road traverses flat valleys between ridges which appear to be composed of diorites and schists. At Mr. Macrae's Croydon Homestead there is an excellent exposure of conglomerates, and the schists, probably of the Archæan "Mosquito Creek" series. The beds strike nearly north and south and dip nearly vertically. They are strongly jointed and often traversed by quartz veins, and a little gold is stated to have been found. The grits seem to be composed of disintegrated granitic material, and afford a good building stone, made use of in the erection of the homes at Croydon. This building stone may be very useful in time as the country becomes opened up. Going easterly from the Croydon Homestead to the Evelyn Copper Mine the country soon changes to schists of dioritic schists.

*Evelyn Copper Mine, M.L. 31.*—About three miles easterly from Croydon Homestead a lode is found striking 30 degrees east, in laminated greenstone country, on which a little work has been done at one time and another, principally by the British Exploration of Australasia, Ltd., Coy., and which has recently been re-opened. The main shaft is said to be sunk to 45 feet but was full of water to 45 feet when I saw it. A good deal of work has been done from this shaft on a shoot of copper ore which appears to have been about 40 feet long. At the time of my visit a portion of the oxidised ore near the surface which had been left when the mine was formerly worked was being taken out of the shaft cutting about 15 feet deep. The lode in this showed 30 feet of ore, mostly oxide of iron and clayey matter, with large bunches and veins of oxides, carbonates, silicates, and some of copper. Some very good ore was to be seen in the shaft, and the manager estimated that he had in bags ready for sale about 50 tons of ore containing 20-21 per cent. of copper.

even two to 14 per cent. of zinc, and up to seven ounces per ton, but no gold. Some carbonate of zinc is visible in places, and there is blende below the water level. I told me that  $7\frac{1}{2}$  tons of ore had been shipped, and he told me that 70 tons bagged and in the ore heaps. I took a sample from a few of the ore bags for analysis by the Mineralogist and Assayer, who found :—

	per cent.
at 100°C	3.86
$\text{SiO}_2$	19.45
$\text{Al}_2\text{O}_3$	3.08
$\text{MgO}$	1.89
$\text{FeO}$	7.04
	20.51
	1.73
Cu	15.18
S	36
Carbonic Acid, etc., $\text{O}, \text{CO}_2$	26.90
	100.00

Assay on dried ore :—

	per cent.
	15.79
	Minute trace
4oz. 15 lwt. 3gr. ( $4\frac{7}{8}$ oz) per ton.	

Analysis shows the composition of the ore to be excellent for purposes, the gangue being self-fluxing.

Mineralogist also examined a number of pieces of ore to determine the minerals present. His report shows the minerals present are chrysocolla, malachite, cuprite, tile, chalcopyrite (little), blende (little), smithsonite, limonite, calcite (thick crusts and veins). The analysis is partly from the chrysocolla, which is water at 100 deg. C.

The mine assays have shown the ore to contain up to 15 per cent. of copper, some of it being pretty rich copper glance. At the water level there appears to have been a great deal of iron pyrites. The dump of this stuff is said by the manager to be an average of seven per cent. copper and six per cent. blende, a good deal of blende.

The ore, though rather short, seems a strong one, and much malachite in it below the water level which requires there is reason to think that a good deal of this is malachite, and may give place at a little lower depth to chalcopyrite. The presence of zinc is a rather serious matter for the ore from this mine, but it seems worth a more examination has yet been given to it. The work in hand at the mine was simply ore-breaking, no development being made. I understood from the manager that he expected to sink a shaft shortly. There is a portable multi-tubular machine, but it had not been used for some years.

There are about eight other shafts on the lease, but these have been successful in getting payable ore. South-main shaft the lode has not been traced beyond the end of workings on the ore shoot, but to the north-east there is a strong brown iron ore outcropping, and some of the shafts sunk have a little copper ore. There seems to me to be a good chance of finding another shoot of ore by prospecting in the vicinity of this shaft, where the brown iron ore outcrop is largest. The country is diorite schist, fairly easy to work so far as the operations shown.

The recorded returns from the Evelyn lease are:—Total for April, 1907, 453.00 tons, value £5,593.

Other leases, now voided, at Croydon are recorded to have produced 40 tons of ore valued at £595.

*Quamby (M.L. 103, formerly M.L. 47) and Keston (M.L. 105)* :—About three miles northerly from the Evelyn mine, Mr. Eyre, Gurr, and Roberts have a lode on these leases about three feet wide, from which green carbonate ore is being worked. They had not time to visit this. Some five tons of ore are stated to have been bagged for shipment, of average assay about 2% copper.

#### STATION PEAK DISTRICT.

From Croydon Station to Station Peak the road traverses mostly plains of granite country covered by diorite hilly ground 4 or 5 miles west of Station Peak. At the centre very little mining work was going on, the principal workings being nearly idle at the time of the visit. There are several reefs, mostly running more or less east and west in a belt of diorite schist country which also runs east and west, and quartzite and slate both north and south of it.

*Pilgrim's Rest Mine, G.M.Ls. 117, 118.*—The main workings of this mine have been in a large open cut on the reef, the top of which can be followed for a considerable distance westward along the ridge of a spur from a high hill in that direction. The open cut workings are between three and four hundred feet in length, and the stone has mostly been worked out to the top of the tunnel by which it was brought to the back of a 20-stake shaft. Mr. D. Bull, one of the owners of the mine, informed me that the reef would average about 9 feet in thickness in the ground now worked, varying from 2 or 3 feet up to 15 or 20 feet, with a little quite in accordance with the appearance of the worked ground. The country is diorite schist laminated more or less parallel to the reef, but the latter has smooth walls and often crosses the country of the country and so is of the fissure lode type. The solid bluish quartz often stained with brown oxide of iron. The deepest workings contains a little copper and arsenic. The course of the reef is more or less east and west, with

to the south, but it bends towards the east end more to the north-east. There are two or more reefs and some cross reefs connecting them, but my examination of the mine was too short to enable me to give a description of each of these. The outcrop to the westward is somewhat broken, the reef being probably either dislocated by neaves or being a series of lenses of quartz *en echelon*.

To the north-east of the battery a shaft has been sunk 132 ft., cutting the lode 8 feet thick at 100 feet but little work has been done from this. There is also a water shaft about 350 feet south from the battery, sunk to a depth of 105 feet, and provided with pumping appliances.

According to the official returns this mine has produced, to April 30th, 1907, 9,888 tons of ore, returning 9,321.87ozs. of fine gold. The gold has been got by amalgamation alone, the tailings being stacked on the ground for future treatment. It was not possible for me to ascertain the value of these tailings, Mr. Bull informing me that assays he had obtained gave an average of 5 to 6 dwts. of gold per ton, while on the other hand the heap is said to have been sampled more than once by would-be buyers who declared that their results were only 2 to 3 dwts. per ton. Taking into account the returns obtained by amalgamation and the nature of the stone it seems probable that the tailings still contain enough gold to be worth cyaniding, and if this is shown to be true by systematic sampling and assaying of the heap, they will constitute an important asset to the mine owners.

The mine has been worked by the owners in accordance with the exigencies of their position in what can only be termed a hand-to-mouth manner, and equipped with the 20-head battery and other machinery upon it from time to time as funds were available from the crushings. The owners have probably done as well as most other people would do in the same circumstances, but have not been able to develop the mine in the systematic and extensive manner required for a reef of this magnitude. It is a case where a fair amount of capital expended in development and equipment is required in order to enable proper and economical mining and milling work to be done, and on the record of the mine there seems great likelihood that if it were given such development it would become a large and important concern. It seemed to me a proposition very well worthy of the attention of investors. In saying this however, I must disclaim putting forward this opinion as anything more than the favourable impression received after seeing parts of the mine and learning its recorded output, my visit having been much too short to enable any sampling to be done of the ore in sight or even to visit the deeper workings. Anyone seriously intending to invest in the mine would require to have it systematically examined on his own behalf to find out what quantities and values of ore are now in sight, and judge for himself whether the future output is likely to

equal the past production in average value of the ore and mining timber are not very easy to get at Station former costing 30s. per cord and likely to rise to 35s. timber is not much good for mining purposes, straight enough for underground work being hard to obtain.

Some gold is said to have been got to the west of the Rest mine in the outcrop of its reef in that direction, the Pilgrim's Progress reef, which is a parallel ore body 5 chains to the south of the Pilgrim's Rest line. Mr. formed me that some gold had also been got to the east reef supposed to be the eastward continuation of the Rest reef.

*Galena Lode.*—Mr. D. Bull informed me that there was carrying a good deal of galena not very far from the Pilgrim's Rest mine, but time did not permit of its being visited.

*Armour's P.A.*—A short distance east of the Pilgrim's Rest lease a little work was going on at the time of our visit. A small cross lode, about 18 inches thick. The quartz was of a yellow colour and showed gold freely, and contained a little iron oxides and carbonates of copper. A small amount of iron had been raised.

#### HONG KONG.

This field lies about 5 miles S.W. from the Pilgrim's Rest Peak, and was quite deserted when our party passed. Although a small party of men had been working very recently, there were on the "Three Prodigals" lease, G.M.L. 134, formerly known as the "Queen Victoria," G.M.L. 97, which included the still earlier "Hong-Kong," G.M.L. 66. They had a two-horse prospecting battery driven by a small engine and boiler. On the 30th April, 1907, they crushed 10.35 tons of quartz and obtained 19.22ozs. of fine gold. There was also an old 2-star mill on the ground and a good rock-breaker. A good deal of work had been done, most of it some years ago by an Englishman. The country is diorite schist lying at the foot of a laminated quartzite.

About a mile to the north of these workings are old ones which were fairly extensive, there being two or three reefs and several cuts into the reefs. There is said to have been a 10-head battery at this spot. These workings appear to be of the old Britannia mine (G.M.L. 82, formerly Empire 105). The following information about this centre is from the report by the Government Geologist, dated 16th March 1906:—

*Hong-Kong, G.M.L. 66.*—Two shafts were sunk, the one 70 feet deep on the underlay of a reef striking N. and underlaying east about 1 in 1. At 55 feet levels were found 10 feet north and the same distance south. The reef d



deg.) below this level and was small in size (7 inches). That the stone from the shaft gave a return of 3ozs. per 5 tons crushed and 10 tons from the drives averaged

The quartz was dense and hard and contained quantities of iron and copper pyrites with a little galena. The second near the northern boundary of the lease and was sunk in the underlay. The recorded production of the Queen's Reef is 89 tons crushed for 82.67ozs. of fine gold.

*Luck, G.M.L. 62.*—This adjoins the Hong-Kong lease on the north. An underlay shaft was sunk on an irregular reef, 12 inches thick, from which about 15 tons of stone were raised, but the returns from the crushing do not appear to have been

*an, G.M.L. 63, Pinyang, G.M.L. 72, and Foochow G.M.L. 73.*—These leases a little work has been done, but the only crushing there is information seems to be one from the Foochow, 10 tons from an open cut and shaft which returned 83ozs. This is not among the official returns.)

*ss, G.M.L. 105, formerly Britannia, G.M.L. 82.*—This small reef about 8 inches thick, running N.W. and S.E. and 15 deg. in dip. A shaft was sunk 55 feet, 226 tons crushed, 1899 and 1900, yielded 335.90ozs. of fine gold, or at the rate of 8ozs. per ton.

*of Morn, G.M.L. 73.*—Reef N. and S., dip east 75deg., 12 inches (2 inches) at surface. Two underlay shafts have been sunk 50 feet apart and connected at the 30ft. level. The shafts met in the northern shaft at 25 feet and was two feet below the reef found again. 16 tons crushed (prior to 1897) yielded 16ozs. of fine gold.

*y, G.M.L. 93.*—The Break of Morn reef is traced into the reef, and a shaft has been sunk on the underlay 40 feet, the reef is 2 inches thick at surface and 18 inches at the bottom of the reef.

*Claims at Hong Kong* are reported to have returned 10 tons of gold from alluvial gold and 9 tons of ore crushed, the reef was closed to April 30th, 1907, being thereby brought to the surface of fine gold from 350.35 tons.

The returns from Hong-Kong centre are shown in the General Report of the Gold Production of the West Pilbara field previous to 1907.

#### PILBARA.

The old Pilbara leases lie about three miles south of Hong-Kong, and at the time of our visit were quite deserted, the only miners in the district being alluvial workers, of whom there were said to be about 25 scattered round the neighbourhood. There has been a good deal of alluvial gold got in this

vicinity, and many men who have worked here return from time to time to try their fortune again. On the south side of granite comes in, and there is a little alluvial tin ore to most of the old leases were on diorite schist and laminated country. The latter is very prominent, and is well seen on the saddle, where the road to Hong-Kong crosses the Black Gully a little distance from Pilbara township. Here the quartz is seen to contain several strong veins of reef quartz up to 12 inches thick, running north 65deg. east, and underlaying to the reef, some of which seemed worth testing for gold. The quartzite has every appearance of being a much silicified zone in the surrounding dioritic country.

*Hidden Treasure, G.M.L. 186 now 25.*—Close to the reef there has been a good deal of work done on a large outcrop of quartz, traceable for a considerable distance along the crest of a low ridge running north-east and south-west. This line of reef is said to run south-west for over two miles to a large white hill, which is a very prominent feature in the landscape. The country is diorite schist, laminated parallel with the reef. Several cuttings into the outcrop have been made, but are now covered up. I understand that they showed the reef to be much more extensive than the big masses of quartz at surface would lead one to suppose. These masses being often portion of the reef outcrop. Some rich stone is said to have been got in the reef. A trial crushing was done with a 5-head battery, which has been abandoned, but after what was evidently a very short trial the work was not done. There is a large amount of quartz available if further testing should show that the reef is treatable in bulk, but the conclusion is that it was too poor. There is no official record of the crushings from this lease.

The following information is extracted from the Geological Survey Geologist's report of 16th November, 1906 :—

The mining centre of Pilbara appears to have been established in July, 1888, and the gullies and flats have been very extensively worked for alluvial gold, some thousands of ounces, chiefly in nuggets, and coarse gold having been obtained, much of which in all probability never officially reported to the Government. The occurrence of veins of intrusive granite in the district has discouraged search for tin, the prevailing geological conditions being identical with those of the tin-bearing centres of the Pilbara Goldfield.

*John Bull, G.M.L. 79.*—On this lease there was a shaft 80 feet on a vein of quartz six to 12 inches thick, carrying iron, lead and copper. A trial crushing of five tons of ore have yielded 26½ ozs. of gold per ton. A copious supply of iron is said to have been got in the shaft. The recorded output from this lease is 233.72 ounces of fine gold from 24 tons of stone.

*Queen Mab, G.M.L. 45 (247).*—There are two lines of reef in this lease, both of which were worked, but the returns seem to have been poor, 100 tons of stone yielding only 28.51ozs. of fine gold.

*Esmeralda, G.M.L. 34 (205).*—There is a strong reef, three feet to eight feet thick in this lease running north-north-east, on which considerable open cut work has been done. Some rich specimen patches are said to have been obtained, but no returns are in the official records.

*Compadre, G.M.L. 29 (200).*—Two parallel lines of reef were worked on this lease, showing strong bodies of quartz. On one an underlay shaft was sunk 90 feet.

*Pioneer Extended, G.M.L. 46 (248), Pioneer, G.M.L. 28 (199).*—A little work has been done on quartz veins in these leases, yielding some rich specimen stone. The gullies on them are stated to have yielded some of the richest results in the district to the prospectors: 24 tons of quartz from these leases are officially recorded as having produced 31.19 ozs. of fine gold.

The official returns from the Pilbarra centre give to 30th April, 1907, a yield of 293.42ozs. of fine gold from 148 tons of stone crushed. The alluvial gold has not been separately recorded, being included, so far as known, in the 3,303.03 ozs. of fine gold of alluvial origin shown in the foregoing table as obtained from the West Pilbara Goldfield generally.

#### WODGINA DISTRICT.

The road from Pilbara to Wodgina is mostly over flat granite country, with frequent rugged hills of granite rising from the plains like islands from the sea. The Wodgina hills are a larger island or chain of islands running north-north-easterly for a distance of over 20 miles and rising steeply to a height of about 700 feet above the surrounding plains, but differ from the smaller hills in being mainly composed of greenstones, metamorphic, and dioritic schists, slates, and ferruginous quartzites, under which the granite has intruded, and through which it has penetrated in the form of numerous dykes of pegmatitic character. The geological structure of this district is fully described, with illustrative maps and sections, in Geological Survey Bulletin No. 23, to which reference must be made for details. The most important feature from the industrial point of view is that the protruded pegmatitic dykes which break through the older Archæan schists and quartzites are frequently themselves stanniferous to a payable degree, and seem besides to have caused formation of true lodes, carrying often rich tin ore, in the superincumbent schists. There is a very strong similarity in this respect to the mode of occurrence of the tin ore at the celebrated Mt. Bischoff tin mine in Tasmania, of which I have personal knowledge, where the ore has been deposited in the vicinity of the contact of an intrusion of quartz and topaz por-

phyry with the very ancient metamorphic sandstones through which it breaks, occurring in the porphyry crevices and seams in the surrounding sandstone, in true veins, and especially along the actual contact of the intrusive rocks. The intrusions at Wodgina appear to be more extensive than those at Mt. Bischoff, and all conditions are favourable for a similar deposit of tin ore occurring. Very large and rich lumps of cassiterite, 50, 60, and even 80 lbs. have been found in the alluvial workings, and already in the lodes several pieces exceeding those in size have been found besides rich lumpy ore in very valuable quantities. It may be that these discoveries already prove that the conditions of formation must have been favourable for formation of rich tin ore in some of the mines at Wodgina, and as this is the case we have every reason to expect good discoveries as the workings open up and deposits more extensively.

*Mt. Cassiterite, M.L. 84.*—The greater portion of the tin ore lies on the Western slope of the hill, the ground being very hard. The country is slate and schist, with numerous outcrops of quartzite. These often contain quartz of lode character, and brown oxide of iron, and frequently show brecciated and distorted structure; as explained previously in the geological notes they were most probably beds of the slate country which have been much fractured by earth movements, and in the fractured zone to come under the action of highly heated waters escaping from the heated interior, which have removed the material and replaced it with silica. The brown iron ore seen in the outcrops is probably partly due to superficial oxidation of the quartzite with oxide of iron by chemical interchange of constituents with iron in solution in the surface waters, and partly to oxidation of contained pyrites. The great significance of the quartzites lies in the proof which they afford of the extensive nature of the agencies in the districts where they occur of the same agencies now generally believed to form mineral lodes, and it is very probable that there may be a close connection between their formation and that of the metalliferous lodes of the locality. In this district where the intrusion of large granitic masses through the older slates seem without doubt to be the cause of the tin lodes being formed, it seems reasonable to suppose that the formation of the country to quartzite was also accomplished by the same cause. The belts of ferruginous quartzite would therefore be regarded as large "lode formations" in favour of which metallic ores might be expected to occur. The top of the hill at Wodgina on which are the tin mines is on quartzitic country of this sort, running north-easterly, between the sandstones on the north-west side and slates and schists on the east side, and this belt is greatly penetrated by numerous dykes.

Along the top of the ridge of the hill, and especially round the cairn near the south-west corner of the Tinstone lease (M.L. 89), there is a large capping of brown iron oxide, which seemed to me to partake more of the character of lode "gossan" than of the "laterite" deposits found capping so many hills in this State. Remembering the occurrence of tin ore in the huge brown iron ore deposit of the "Brown Face" at Mt. Bischoff, for many years the mainstay of the Mt. Bischoff mine, this brown iron ore seems to me to be worth very careful prospecting for tin.

On the Mt. Cassiterite lease good alluvial tin ore was found in Ogilvie's gully, and there were also alluvial workings west of the western boundary in a gully running up into the south-west corner of the lease. In this corner a little work has been done on some tin-bearing veins close to a pegmatite dyke—some good tin ore was obtained, associated with black tourmaline and green pinguite, but the ground is not sufficiently opened to give a good view of the occurrence. The main workings are on a lode in the north-west corner of the lease. Here two tunnels have been driven from opposite sides of the ridge on the course of the lode—which runs nearly east and west—to form the top level when connected, and on the west side another tunnel has been put in lower down the hill. The lode is a true fissure vein from two feet to as much as 10 feet wide, with smooth walls, cutting distinctly across the stratification of the country. The veins stuff is mainly quartz, but there is much soft lode matter as well, mostly chlorite and kaolin, in which the best ore has been found. The richness of this ore will be seen from the fact that 41 tons of clean tin ore are stated by the owners to have been obtained from this lode without the aid of machinery by hand-picking and the following process. The soft lodestuff is thrown upon a round sieve worked by hand, on which it is shaken with a motion similar to that used in panning off alluvial gravel in washing for gold or tin with the ordinary prospector's dish, but in this case the material is dry. The fine stuff goes through the sieve, and the lighter part of the coarse material comes to the top and is allowed to escape over the side of the sieve. After working for a little time there is a quantity of coarse lumpy tin ore left on the sieve, which is then hand-picked and bagged. The finer material passing the sieves might be treated on a dry-blowing "shaker" to obtain the finer tin ore, but at the time I saw the work in progress only the sieve was being used. The extreme roughness of the treatment is obvious, and the tailings still contain much ore, and are being saved for washing later on.

The owners have the erection of a dressing plant under consideration, and have lately been successful in finding a good supply of water by boring in the valley of McCarthy's Creek, a little distance above the township. At present the ore is sent down from the hill by means of a "flying-fox," or aerial tramway; and timber for the mine is taken up the same way. The mine will be workable from

tunnels for a long time, and is at present one of much profit. It has paid its way out of tin produced, even with the prime cost of ore dressing above described. About 23 men were constantly employed in it at the time of our visit, and government work was being done, the underground workings of some considerable extent. The official record of output from this mine to 30th April, 1907, is 55.92 tons of beryl valued at £6,048 (see table below).

*Tinstone, M.L. 89.*—This lease is on the eastern slopes of the hills, and though it adjoins the south-east corner of the Cassiterite lease, the ground is so steep and rough that if the latter mine put up their proposed battery near the top of the ridge, ore from the Tinstone would have to be carted from the east side right round the north end of the ridge, a distance of some seven miles, or else carried over by an aerial tramway to reach it. Some alluvial tin ore has been got in the past from this lease. The large outcrop of brown iron ore near the south-west angle of this lease has been already mentioned as being a hard gossan with frequent veins of quartz traversing it. It seemed to me very like the capping of what may properly be called a very large "formation." A little distance down the hill from the iron ore a considerable outcrop of purplish-coloured lepidolite rock seemed to be of the nature of a vein or dyke, and is doubtless connected with the pegmatite dykes. This rock occurs in other parts of the Wodgina district in much the same way, and may be regarded as a very favourable indication for tin, the presence of lithia mica with tin ores having been often noted in the tinfields. The lepidolite rock is in considerable quantity, and is to be often fairly pure, so may become of some value in the future as a source of lithia, for which purpose this mineral has a considerable value, varying with the amount of lithia it contains. The value, however, too low for shipment under present conditions to port.

Two tunnels have been driven on a lode running north-east and south-west, and connected by a rise. The country is a laminated schist, the lode cutting the lamination obliquely, and the walls well smoothed. It has considerable underlay, and is composed of soft kaolinic matter with quartz chlorite and tourmaline, containing rich coarse tin ore very similar to that above mentioned in the Mt. Cassiterite lode, and which is separated in the same manner. About 18 tons of ore are said to have been shipped from the workings, some of which does not yet appear to have been included in the returns to the Mines Department. The lode is well worth opening up on a more extensive scale than has hitherto been attempted.

The official returns show an output from this lease of 18 tons of tin ore valued at £1,070.



*wealth, M.L. 85.*—A short distance west of the Tinstone her outcrop of lepidolite is seen, associated with quartz, and west still are some workings on a lode of kaolin and some containing some very nice tin ore in parts. The lode is not yet at all extensive, and very little can be said of it. The recorded returns from this lease are 2.95 tons of tin ore valued at £348.

*L. 90.*—This lease lies north of the Tinstone, and some work has been done in a gully running northward. The brown iron ore capping shown strongly on the top of the west spur towards the south boundary, and below this on the side of the spur a big vein of kaolin, quartz, and felspar is exposed, dipping very flatly under the capping. The lode of this lode is well smoothed, but the footwall seems to be kaolinised pegmatite, the veins being very probably on the surface of a dyke of this rock. A winze was being sunk in 1891 when I visited the mine, and was down 20 feet in it, the matter carrying a little tin ore disseminated through the mass. This occurrence of tin ore through the mass of the dyke is noteworthy, as it will probably recur freely in the field, and these dykes are very numerous. Portions of the lode therefore, turn out to be worth working. There is no doubt about this lease.

*Dawson's, M.L. 110.*—Considerable alluvial working has been done in a gully running north-westerly through this lease. In this gully are some workings on two lodes which have yielded very good tin ore. The ore is mostly in soft chloritic matrix. The Mt. Cassiterite and Tinstone mines, but tin is also found in the hard quartz. The lode seems to run about east and west with southerly underlay. A shaft has been sunk 60 feet, and put in from it to the northern lode, which is here a dyke of quartz and chlorite. There seems to be a large mass of quartzite "formation" running with the lode, but there is one out-cropping very strongly on the steep slope which appears to run off at an angle to it. It is by no means clear how many lodes there are, and what are their relations to each other and to the ferruginous quartzites. The rock all through the workings is greatly veined with quartz, and much silicified. It is a great deal of it might well be regarded as "lode rock" rather than "country." A good deal of mining will have to be done before the nature of this ore occurrence can be fully ascertained. Messrs. May and Dawson have had some very good ore, and about 20 tons of clean tin oxide by handpicking and sorting. The ore is sent down from the mine by a "flying fox" to the creek, where it is sieved and some of it washed in a stream. Some of the ore, however, is pretty hard, and will require crushing to operate the tin. The output of this mine has either been sent in to the Mines Department, or is included in the Tinstone Claims in the following table.

## Quantity and Value of Black Tin Ore

No. of Lease or Claim.	Name of Lease or Owner.	1905.				Lode.	Stream.	Total.	Value.	Lode.	Str.
		Lode.	Stream.	Total.	Value.						
		Tons.	Tons.	Tons.	£	Tons.	Tons.				
77	Stannum .. ..	..	4.35	4.35	255	..	..	..	..	..	1
84	Mount Cassiterite .. ..	..	13.85	13.85	1,132	23.42	..	..	..	..	..
85	Commonwealth .. ..	..	..	..	..	2.95	..	..	..	..	..
88	Chamberlain .. ..	..	..	..	..	.35	..	..	..	..	..
89	Tinstone .. ..	..	..	..	..	3.60	..	..	..	..	..
93	Mount Cassiterite North .. ..	..	..	..	..	6.12	..	..	..	..	..
	Sundry Claims .. ..	..	13.25	13.25	1,075	.15	..	..	..	..	6
	Mullner's Claims .. ..	..	..	..	..	..	..	..	..	..	..
	Total .. ..	..	31.45	31.45	2,462	36.59	..	..	..	..	8
86-87	H. M. and Anchorite .. ..	..	26.00	26.00	3,425	1.80	..	..	..	..	6
	Sundry Claims .. ..	..	44.95	44.95	5,500	..	..	..	..	..	5
	District Generally .. ..	..	..	..	..	..	..	..	..	..	..
	Total .. ..	..	70.95	70.95	8,925	1.80	..	..	..	..	12

ally Reported to the Department of Mines.

April 30th.		Total.			
Total.	Value.	Lode.	Stream.	Total.	Value.
Tons.	£	Tons.	Tons.	Tons.	£
..	..	..	6.10	6.10	461
18.65	2,238	42.07	13.85	55.92	6,048
..	..	2.95	..	2.95	348
..	..	.35	..	.35	60
7.10	710	10.70	..	10.70	1,070
..	..	6.12	..	6.12	643
10.47	967	.15	30.17	30.32	2,710
1.26	126	.63	.63	1.26	126
37.48	4,041	62.97	50.75	113.72	11,466
..	..	1.80	32.30	34.10	5,445
..	..	..	50.60	50.60	6,030
..	..	..	.90	.90	94
..	..	1.80	83.80	85.60	11,569

*Anchorite, M.L. 87, and H.M., M.L. 86.*—On these considerable amount of tantalite has been obtained sluicing, water being pumped on to the ground from McCarthy's Creek, by means of a boiler and pump. is mainly schistose diorite, but both leases are traversed by a dyke of pegmatitic granite running about north and south, the matrix of the tantalite. In places the dyke is a fine-grained albite (soda-felspar) while elsewhere it is composed of quartz. An open cut in the southern part of lease No. 86 shows dykes of albite with fine-grained granitic rock between them. The albite had separated out on the sides of the granitic rock. Tantalite was very freely visible in the albite, in coarse grains up to many pounds in weight. Some very heavy lumps of tantalite obtained, one weighing about 5 cwt., evidently derived from the weathering down of the pegmatite. Towards the north of lease there is another set of workings where tantalite has been got in a big outcrop of quartz and felspar. Lepidolite rock is seen also in the vicinity.

The quantity of tantalite reported from these leases is about 50 tons of nominal value £5,445, but most of the 50.60 tons is the foregoing table as from Sundry Claims was also obtained from alluvial workings on the same ground. The actual sale of tantalite in Europe varied a good deal, and some of the shipment of tantalite yet stored in London without having been placed on the market. These mines were worked energetically for a little time, but there was a market for the tantalite, but very soon consumer demand was filled, and the mineral could not be sold. There are some 10 tons of the ore belonging to the lessees, and some 10 tons belonging to alluvial workers still on the leases bagged up for shipment when there is a price to be had for it.

The industrial uses of tantalite are at present very limited, but the demand for the mineral is therefore small, but metal has some very remarkable properties which will doubtless lead to its more extensive use as time goes on. The deposit of tantalite seems to be one of the most extensive discoveries of the century, and will doubtless be worked as the demand for it becomes established. The ore in the solid albite rock is dressed to separate it from the gangue, by processes similar to those used in concentrating tin and wolfram ores.

It is somewhat remarkable and very fortunate that on these leases has been very free from tin ore, and the bearing lodes of this district have hitherto been very free from tantalite, as the separation of the two minerals is impossible by ordinary washing processes and difficult in the metallurgical processes.

*Stannum, M.L. 77.*—The Stannum leases are about 1 mile north of the Wodgina group above described, and were discovered at the time of our visit. They are near the head of a large

comes out on the west side of the range, by going up which they may be reached with carts or other vehicles. There is a great deal of the metamorphic quartzite country in the vicinity, together with massive and schistose greenstones, through which have been intruded masses of porphyry and felsite of considerable extent. Some of the felsite is schistose, very possibly from the same causes which have caused lamination of the greenstones. There are also pegmatite dykes similar to those at Wodgina penetrating these older rocks, and the tin ores are in close connection with these.

Some alluvial workings have been made in the gully in the N.W. angle of the Stannum lease, and several shallow cuts and shafts have also been excavated on veins carrying tin ore, on the hillside to the south of these. There seem to be several rather flat-lying veins of small thickness cutting through the felsite and greenstone. They consist of quartz, silvery mica, feldspar, and purplish lepidolite and carry some very nice tin ore, but seem more likely to be small pegmatitic dykes than true lodes. If they were a little larger they would probably be worth working, but I am afraid those I saw are rather too small to be payable. The matrix is pretty hard, and would require crushing in order to liberate the tin ore. The Government Geologist's map of the Stannum tinfield (Geological Survey Bulletin No. 23) shows a long pegmatite dyke running south from the above workings, and prospecting along this would be well worth doing.

The output of tin ore recorded from the Stannum group of leases is 6.10 tons valued at £461.

*Other Tin Discoveries.*—The Government Geologist's report (Geological Survey Bulletin No. 23) mentions several other tin discoveries in the Wodgina district, which I did not visit, but so far as I could learn none of these have had much work done upon them since he described them. Close to the road from Wodgina to Port Hedland about a mile from the township I noticed an outcrop of quartz and lepidolite on which a little work had been done, and which was stated to contain some tin ore. It seemed worth opening up more thoroughly, being quite similar to others of the tin-bearing pegmatitic dykes near the township.

The discovery of tantalum minerals and tin ore at Mt. York, 20 miles N.E. of Wodgina, referred to in the Government Geologist's report, is worth bearing in mind when considering the Wodgina district, as showing that the stanniferous area is probably an extensive one. Though time did not permit a visit to the Mt. Francisco district about 26 miles south of Wodgina, information obtained at the latter place from the prospectors, and specimens seen, showed that good tin ore had been got there also, and good specimens were also shown us from Sifflet's P.A., between Wodgina and Mt. Francisco. The ore in both these cases was enclosed in hard lode-matter of granitic structure which would require crushing in order that the tin ore might be liberated.

Though much of the soft lodestuff in this field can be puddling without crushing, there is harder material most of the lodes which requires crushing to set free the tin. A crushing and dressing mill is therefore very much needed in the district. It is probable that the Mt. Cassiterite Co. will put up machinery for this purpose before long, on the western side of the hill, but owing to the steepness of the intervening country a mill will not be easily accessible from the mines on the eastern side for which a battery near the Government well on that side would be much more convenient. This site would also be much more accessible for prospectors sending in ore from Mt. York and Mt. Cassico. Recent boring has shown that good supplies of water can be got on either side of the hill. Firewood is obtainable more easily on the eastern side than on the western, there being a fair quantity of river gum timber on the flats of the Western Turner River.

Carriage of ore and stores to and from Port Hedland is a distance of 75 miles, costs £8 a ton. Mining timber is scarce and costing about 6d. per lineal foot.

#### WODGINA TO TAMBOURAH.

The road from Wodgina towards Tambourah follows the Western Shaw goes easterly for 10 or 12 miles over flat granite plains, towards the high rough country lying between Lalla Rookh and Marble Bar, and then turns south-south-west, still over granite country, keeping a few miles west of the Shaw River region, to a short distance south of the Woodstock Station it turns into the rougher country and crosses through it to the basin of the Shaw River. This part of the hilly country is composed of dioritic and metamorphic schist and quartzite, with frequent igneous intrusions. The ferruginous quartzites seem to be unconformable on or close to the contact of the schists with the granite.

At Mr. Peard's Woodstock Station we were shown several samples of chrysotile asbestos from the Pilbara Asbestos Co. discovery, about 25 miles to the north-east, and some copper ore from the hills about 4 miles from the homestead, but we had no opportunity of visiting these finds. The asbestos discoveries have been visited by Mr. P. C. Riches, Acting Inspector of Mines, and his report upon them is quoted later on. The copper ore was a green carbonate of copper. Good "tile ore," oxide of copper, was also shown, obtained from a lode at Tambourah.

#### TAMBOURAH.

This old mining centre has been quite deserted for some years so far as any serious work is concerned. It is described in Geological Survey Bulletin No. 23 with the geological map showing the lodes and country. The reefs are therefrom to form a group of parallel veins running slightly



of north parallel with the lamination of the enclosing country and dipping at high angles to the eastward. The veins are numerous and some of them persistent for long distances, but mostly small. They are roughly parallel to the contact between the schistose greenstone country in which most of them occur and the intrusive granite on the west side of the field, but the latter also sends intrusions into the greenstone and encloses numerous detached masses of it, and some of the reefs are in the granite. The Government Geologist draws special attention to the fact that many of the reefs traverse both greenstone and granite country indiscriminately and "are likely to be as persistent in depth as deposits of the kind can ever be, and they are not liable to be cut off by the granite as might have been the case had the formation of the reefs preceded the intrusion thereof." The reefs seem to have carried a good deal of iron and copper pyrites, and to have gone down strongly into the hard country enclosing them, but all the workings were of small depth. There was a 10-head battery on the field which has been removed, and a rusty Tremain Mill still is standing on the old Tambourah King lease.

The following table is taken from the Government Geologist's report in Geological Survey Bulletin No. 23 :—

*Summary Table showing the Yield of the Tambourah Reefs up to the end of 1905.*

Name of Reef.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Brilliant ... ..	35'00	21'60	·61
Federal ... ..	11'00	15'25	1'38
Kirkpatrick ... ..	88'0 )	208'50	2'36
Kushmattie ... ..	140'50	271'65	1'22
Old Australian ... ..	5'50	70'10	1'36
P.A. ... ..	...	*	
Quartz Claim 146 ... ..	...	† 43'71	
Sundry Claims ... ..	639'25	‡ 1,264'91	1'42
Tambourah King ... ..	86'00	154'0 )	1'79
Tambourah United § ... ..	34'0	37'68	1'10
Western Chief ... ..	654'0	763'90	1'16
Western Chief No. 18 ... ..	102'00	249'31	1'16
World's Fair ... ..	412'00	505'60	1'22
Total ... ..	2,253'25	3,606'21	1'60

\* Returns probably included under the Western Chief Mine. † Dollied and specimens. ‡ Includes 20 ozs. of dollied and specimens and 333'71 ozs. of alluvial. § Exact locality unknown. || Includes 130'14 ozs. from tailings.

The smallness of the reefs and the hardness of the enclosing country were probably the principal causes of the abandonment of this field. The average value shown by the returns is fairly good, though below the general average of the Pilbara fields, and, under more favourable working conditions, there seems reasonable hope that this district might yet be resuscitated.

## WESTERN SHAW.

Our party was not able to visit the Western Shaw field, which lies about five miles south-east of Tambourah. Like it, has been deserted for some years past. The Government Geologist's report (Geological Survey Bulletin No. 23) shows it very similar to the Warrawoona field in structure. A large quantity of alluvial gold is believed to have been won by dry-bulb after the first rush in 1891. There are several well developed reefs of considerable length, conforming with the foliation enclosing schists.

*Synoptical Table of the Gold Yield of the Western Shaw**(From Geological Survey, Bulletin No. 23.)*

Name of Reef,			Ore crushed.	Gold therefrom.	P.
			tons.	ozs.	
Imperial Leases	...	...	1,221'00	1,146'29	
Trafalgar	...	...	30'00	90'00	
Total	...	...	1,251'00	1,236'29	

The Government Geologist states that there is very little gold within the vicinity of the mines, whilst timber for mining purposes would have to be carted at least 20 miles.

## TAMBOURAH TO COOGLEGONG.

Going from Tambourah eastward to Hillside Station soon leaves the belt of schist and quartzite and comes on to granite again. On the contact there is a development of quartz and jasperoid quartzite, and for a time shows a rough lamination parallel to the schists. The most prominent features in this part of the Black Range are two huge dykes of diabase, the Eastern one of which extends in a north-north-east direction in almost a straight line for about 25 miles, as a rugged abrupt ridge from the granite plains and covered with blocks of black stone, bare of vegetation. It is cut right across at Hillside Station by the Shaw River, where it is clearly a coarsely crystalline quartz diabase dyke breaking through the granite country. The western dyke is not quite so prominent, seemingly equally strong, and lies about four miles west of the Black Range. From Hillside Station the road runs north over granite country, to Cooglegong.

## COOGLEGONG AND SHAW TINFIELD.

The Cooglegong and Shaw Tinfields occupy a very large area of country, scattered widely over which are several alluvial workings, mostly very shallow, which

give employment to about 125 men. At the Cooglegong centre the workings are on watercourses running into the Cooglegong Creek. Roberts' claim, which was visited, is said to be a characteristic example of the ordinary occurrence of the tin. The ground was about six feet deep, with about a foot of rather angular quartz and felspar "wash" on the bottom, containing a very fair amount of somewhat coarse subangular tin ore. The more leamy surface stuff also contains a little fine tin ore. The surface layer is often richer, through concentration of the ore, owing to gradual washing away of the lighter soil, and a good deal of surface ground has therefore been worked by dry-blowers who have not attempted to sink for deeper deposits. The deeper leads on the granite bottom, like those at Moolyella, belong to a time when the watercourses had cut down into the bedrock—since then there has been a good deal of filling up of these older channels, and the present watercourses often run above them. No really deep alluvial ground has yet been found, but the presence of buried leads below the existing watercourses points to their discovery being possible in any of the larger alluvial flats. The surface tin-bearing soil is mostly worked by dry-blowing, but the more clayey stuff from the leads has usually been treated by puddling.

Near the 2-Mile Well there is a good deal of dark-coloured mica schist, striking north-north-east and south-south-west which seems to be resting on the granite, but is probably portion of an older rock under which the granite has been intruded. Penetrating this schist there are several veins of felspar and quartz carrying tin ore. A little work has been done on some of these "lodes" at a point about a mile north-east from the well. Fine, small parallel veins up to 12 inches thick are seen lying flatly one above the other in a width of about 100 feet, some of them showing enough tin ore to be payable if they were a little larger in size. The felspar is albite, as in the very similar case of Thomas' lode at Moolyella, and the tantalite lode at Wodgina. The stanniferous dykes of this type are, without doubt, the source of much of the alluvial tin in this district, and they are, therefore, well worthy of notice from prospectors, in the hope of some of them being found large enough and rich enough to be worked as lodes. Seeing how widely the tin ore is scattered it seems probable that the stanniferous veins are very numerous, and among them there should be good hope of a payable discovery.

West of Cooglegong, on the fall of the Shaw River, several men were working near the "Shaw Patch" well, getting tin ore from the shallow ground, and also from somewhat deeper leads.

It has been proposed to work the beds of the Shaw River and Cooglegong Creek for tin ore, and seeing that these streams are the main waterways of the district, taking the drainage from a huge extent of stanniferous country, and being the main channels into

which all material denuded from the surface by the action of running water must have been swept for ages, to be concentrated by a long-continued process of natural growth. There seems every reason to believe that they must contain a considerable amount of tin. The beds are, however, very wide, and of considerable depth with light gravel and sand which would have to be removed to get at any payable stanniferous "wash," so that working is a proposition requiring handling on a fairly large scale to have any hope of success. Ordinarily there is no water in the streams, except in pools here and there along them, but after heavy rains to which the district is subject, they may be flooded, and deep rivers which would sweep away and overturn any machinery and sluicing appliances that could not be very easily removed.

I was not able to get any information of value as to the prospects of tin ore obtainable in the beds of these streams. It is said to have been sunk in the Cooglegong bed, but were not successful on account of the influx of water being too great for machinery. I am very doubtful, however, if any determined effort has been made to search for tin in these river beds, as it shows to be a very difficult matter to sink deep enough to be able to obtain satisfactory samples of the bottom "wash" even if the bottom is pretty heavy. A good deal of testing could be done by sinking a boring.

Should it be found on trial that there is enough tin in the beds to be worth putting machinery upon them, the deposit could be readily worked by dredging, provided also, that it was possible to get there was a sufficient supply of water for this purpose from the gravels. If a large water supply is not so obtainable readily, the problem of devising a profitable method of working would be a difficult one. The whole proposition requires very careful preliminary investigation.

The following table shows the recorded production of tin ore from the Cooglegong and Old Shaw Tinfields to end of 1907 :—

	1906.		1907 (to 30th April).		Total to end of 1907
	Stream Tin.	Value.	Stream Tin.	Value.	Stream Tin.
Cooglegong ...	tons. 147·09	£ 16,284	tons. 40·60	£ 4,462	tons. 948·0
Old Shaw ...	...	...	...	...	220·7
Total ...	147·09	£16,284	40·60	£4,462	1,168·8

m Cooglegong, across the Shaw River, the country to rough hills of greenstone schists, etc., of the Warra. An alluvial gold "rush," known as the "Keep-it-this vicinity, and a little further north are the Asbestolately acquired by the Pilbara Asbestos Coy. The y, according to the geological map, extends some 15 m Cooglegong down the Shaw River, but the boundary d the greenstone schists then turns back again to the ng crossed on the road from Cooglegong to Marble Black Range Well.

#### NORTH SHAW.

Cooglegong to North Shaw the road lies over s with frequent rocky island-like hills of granite from them. Near North Shaw dioritic schists are en- rich form the country enclosing the auriferous and efs of this centre. The old North Shaw township is ed, and the old mines have all been abandoned. The eologist has quoted Mr. Becher's report on these at were working, in Geological Survey Bulletin No. 23. mines were the Eldorado (G.M.L. 88), Eldorado West , Bertha (G.M.L. 431), Auraria (G.M.L. 394), and M.L.s 211-212). On these there are fairly strong east on which some work has been done to depths not more The stone contained a good deal of sulphides of iron, ad, and some silver ores, and some of it was of very gold. Mr. Becher's report mentions that on the Nil lease (G.M.L. 378) "a small very highly mineralised of about eight inches to 18 inches outcrops flatly ase of low hill; probable course east and west and n," and that samples gave him good prospects of gold. ely to be the same ground that has lately been taken Bonner and Royer as a prospecting area for copper ese prospectors have opened up several copper-bearing of which an old shallow shaft had been sunk, which is of the old Nil Desperandum workings. There is an vein of quartz and copper ores in this shaft corres- r. Becher's above description. About 20 feet north of ver, the present prospectors have opened up a parallel also dipping flatly northward, up to two to three feet ne very good "liver" or "tile" ore, oxide of copper, green carbonates of copper. The ore vein is often 10 wide, the lode carrying a "horse" of kaolin in the ap of sever tons of very good export ore had been the workings, which are still merely shallow open cuts o, and this was being bagged for shipment at the time These two lodes have been traced some distance up the ward, showing fair copper ore that seems well worth rther, and to the south of them is another vein running

north 10 degrees west, which contains some nice oxide ore with quartz, and seems a fairly strong lode. There are showing copper ores over an area of two or three miles in vicinity, requiring more prospecting to show which of them is of value. Near the top of the hill, to the east of the lode, there is a large "formation" of much contorted schistose dolomite, which shows a few stains of copper carbonate, probably some close connection with the lodes which show into it. Very little work has been done yet to open up the lodes, but from the plentiful occurrence of green copper ore and the good value of the ore already obtained, they seem worth testing more thoroughly.

On the day of our visit another lode was found some distance from the above with good copper ore in the outcrop. At the time to visit Watson's P.A., about two miles further west, some very good brown oxide ore ("tile" or "liver" ore) was seen, some of which showed gold freely through it. The veins are from three to 15 inches thick.

A sample of the "liver ore" from Watson's mine given to the Cooglegong was analysed by the Government Analyst, showing :—

No. 3366.	Moisture	...	...	...	...	...	...
	Silica $\text{SiO}_2$	...	...	...	...	...	...
	Alumina $\text{Al}_2\text{O}_3$	...	...	...	...	...	...
	Lime $\text{CaO}$	...	...	...	...	...	...
	Iron $\text{Fe}$	...	...	...	...	...	...
	Copper $\text{Cu}$	...	...	...	...	...	...
	Sulphur $\text{S}$	...	...	...	...	...	...
	Oxygen $\text{O}$ , Carbonic Acid $\text{CO}_2$ , etc.	...	...	...	...	...	...

No Nickel, Zinc, or Lead.

On dry ore the assay is—

Copper	...	...	...	...	...	4
Silver	...	...	...	...	29ozs.	45dwts.
Gold	...	...	...	...	0ozs.	0dwts.

Messrs. Maher and Miles, of Marble Bar, were good enough to give me a copy of the account sales of parcels sold from Royer's P.A. to the Fremantle Smelting Works, which gives interesting figures, not only of the value of the ore, but also of the marketing and smelting it.



nt, 6th February, 1907.			£ s. d.	£ s. d.	£ s. d.
cwt. qrs. lbs.					
Ore = 19 3 23					
= 18.75 = 18.71 units ...			0 19 8	18 10 5	
7 ... ..			4 0 0	0 12 10	
£ s. d.					19 3 3
g charges ... 2 2 0					
and wharfage 1 4 0					
e, harbour					
es, insurance,					
ommission ... 7 14 0					11 0 0
			...	..	
tons. cwt. qrs. lbs.					8 3 3
Ore = 1 0 3 4					
r 25.00 = 22 per cent. ...			0 19 8	22 12 8	
- 3					
... 13 „			4 0 0	0 10 3	
£ s. d.				23 2 11	
g charges ... 2 2 0					
and haulage 1 8 10					
ge, harbour					
ges, insurance,					
ommission ... 7 14 0				11 4 10	11 18 1
			...		
ment, 25th March, 1907.					
tons. cwt. qrs. lbs.					
r Ore = 3 14 0 0					
= 29.6 per cent.			0 19 9	108 19 5	
£ s. d.					
g charges ... 7 8 0					
, haulage, etc. 5 1 6					
ge, harbour					
ges, insurance,					
ommission ... 28 9 10				40 19 4	68 0 1
			...		
ment, 5th April, 1907.					
tons. cwt. qrs. lbs.					
er Ore = 2 0 2 25					
= 20.85 ...			0 18 0	38 4 1	
£ s. d.					
g charges ... 4 1 5					
, etc. ... 2 3 3					
ge, harbour					
ges, insurance,					
... 16 1 10				22 6 6	15 17 7
			...		
f 7 tons. 15cwt. 1qr. 24lbs.			...		103 19 0

Summarising these we get—

	Costs.	Gross Value.	P
	£ s. d.	£ s. d.	£ s. d.
7 tons 15cwt. 1qr. 24lbs. net of ore = 7.7732 tons ...			
Smelting charges ...	...	189 9 8	...
Steamer, freight, wharfage, and haulage at Fremantle	15 13 5	...	2 0 4
Cartage, handling at ship- ping port, insurance, and commission ...	9 17 7	...	1 5 5
	59 19 8	85 10 8	7 14 4
Total, net £103 19s. Od. =			

In the above method of reckoning the deduction of of copper from the assay value is made before computing value. The average price realised was 19s. 3d. per unit, full assay value was £2 17s. 9d. more than the above g or £27 5s. 3d. a ton, and the smelting charges were also greater by the same amount, thus coming to £4 18s. 1d. and making total costs, as reckoned against full assay 17s. 10d. The costs of mining and hand-picking the ore and filling and sewing bags, are not included in these figures are chargeable against the net return. The cartage to Port was done at a very low figure for the district, viz., £6 this favourable rate could not be always obtained. At the prices of copper the ore would have to have an assay value on 17 per cent. to pay expenses of mining, bagging, and smelting. It is clear, therefore, that no extensive copper can be expected until this excessive figure can be greatly reduced. The best hope is that the mines will prove themselves able to run a small smelting furnace on the spot, but until they are opened up than is yet done this cannot be thought of. If copper discoveries are made in the field, however, the case may at any time assume a different aspect.

The official record of gold returns reported to the Mining Department to end of April, 1907, from North Shaw is:—

Alluvial ... ..	7.53 oza. fine.
Dolled and Specimens...	567.06 "
Ore treated, 351.45 tons for	674.72 "
Total 351.45 ..	1,249.31 "

#### NORTH SHAW TO MARBLE BAR.

The route followed ran eastward to the Black Range there joining the road from Cooglegong to Marble Bar soon after leaving the old Eldorado mines at North Shaw. The road passes on to granite country, which continues to Range Well. Not far from North Shaw, a big dia-

ar to that forming the Black Range. North range Well we come first upon a coarse con- nite and greenstone boulders, which is very pro- basal beds of the Nullagine series. The country ly from here onwards nearly to Marble Bar, and ly composed of flat-lying slates, conglomerates, e Nullagine series. This interesting stretch of bed more fully in Geological Survey Bulletin No. eading of the Just-in-Time mining centre. This visited by me, no work being in progress there. Geologist in his Bulletin has draw attention to contents of some of the basal conglomerates of the at this place, and has described three of the mines work was done on these conglomerates. The re- small, only 60 tons having been returned as crushed 30ozs. of gold (unrefined). Mr. Maitland remarks of an auriferous conglomerate, in the same strati- at least 50 miles distant from Nullagine where eal conditions prevail, would seem to encourage rection of carefully prospecting other portions of rs of the series, which occupy such an extensive n-west district."

#### MARBLE BAR DISTRICT.

ical Survey report and map (Geological Sur- No. 20, pp. 105-120) of the Marble Bar o possess a rather complicated geological structure. separate sorts of rock having been distinguished he main country on the west side of the field is amorphic schists, and on the east side granite, but ted by numerous dykes of porphyry, diabase, and arts of the district overlaid by lavas, agglomerates, belonging to the Nullagine formation. The cele- Bar," on the Coongan River, is a huge outcrop of uartzite referred to previously in the geological g the schist. It is very regularly laminated, and oloured in shades of pink, red, and blue-black shades. highly suitable for ornamental lapidary's work. e contact of the granite and the schist, and running d south for about three miles in length, there lies belt of sheared greenstone very similar to the schis- d amphibolites of the Eastern Goldfields, and along succession of quartz reefs, on which a good deal of s been done, and which have yielded a very con- nt of gold. The reefs have various directions of er greatly in the amount of their underlay. The country is hilly—though none of the hills are very aversed by numerous ridges and gullies. In many ere has been a lot of working for alluvial gold, but

reliable returns of the amount of this which was workable. The ground worked was very shallow and according to local report gave very payable returns.

At the time of our visit the mines at Marble Bar were all idle with the exception of the Coongan Star on which a little work was being done. The description in Geological Survey Bulletin No. 20 still holds good and renders it unnecessary for me to again give particulars of work done in each, but a few notes may be given upon the visible.

To the north of Marble Bar the road from Port Hedland passes the old *White Angel* mine (G.M.Ls. 649, 210), the shaft of which now serves as a settler's homestead well: it has not been worked for many years and I obtained no information about its workings or returns from it, if any. Further south, within a mile of Marble Bar township, the old *Band of Hope* (G.M.L. 533) mine (G.M.Ls. 2, 4, 482, 483) was all on a strong north-south reef running through several leases and showing free outcrop. On the *Ironclad* lease (G.M.L. 2) the Geological Survey Report notes five well-defined reefs altogether, in the schist country. A considerable amount of work has been done on the outcrops of the reefs, and large amounts of quartz left uncrushed. I was informed that prospects equal to 10 dwts. per ton could be obtained from some of this stone, but cannot believe that much of this average grade has been left untouched where it was so cheaply obtainable. The probability is that the owners took out the richer stone which they could get it and left standing only that which they would pay them, and it is quite likely that parts of the reef will occasionally prospect well. The Government Geological Survey gives the returns from the *Ironclad* reef as 1,441.57 dwts. from 2,040.50 tons crushed, or an average of 14 dwts. per ton. When mining facilities in the district have been so improved as to permit the profitable working of low grade stone it is not surprising that much of the quartz left untouched formerly will be crushed. The nature of the workings gave me the impression that the miners had followed richer ore occurring irregularly rather than that they had worked out definite ore-shoots.

The main reef is three to six feet wide and underlies the country flatly to the westward; the quartz is in short blocks and boulders, as if the reef had been much fractured and broken up. That the reefs are older than the Nullagine series of strata in the schist country, and that there have been movements of the crust sufficient to considerably bend and crumple the strata, it is only to be expected that the reefs might be broken and twisted by the same movements, and this is a plausible explanation of many of their irregularities.

ned that the old vertical shaft of the Ironclad mine  
et deep, and that there was at one time a battery  
heads of stamps on the ground.

e Ironclad is the old *Bohemia* mine (G.M.L. 6) on  
allow work has been done on the outcrop of a very  
There is a large amount of quartz here readily  
presumably too poor to be worth crushing at the  
were working. There are also workings some three  
feet further east on a flat body of stone which may  
to the same reef. The stone contains much oxide  
e of it shows a little copper pyrites.

General mine (G.M.L. 8,485) still further south, the  
north 55 degrees west with dip to south-west, and  
dyke of diabase. The main shaft is said to have  
feet deep, and the first 250 tons crushed are stated  
4½ ounces of gold per ton.

ard Bound mine (G.M.Ls. 472, 579, 638) had a lot  
the side of a hill on which a flat reef crops out  
parallel to the slope of the hill. Near the foot of  
t about 80 feet deep (water level) is said to have  
r feet wide and worth about 18 dwts. per ton. As  
entioned reefs there is a large amount of quartz  
various workings which has evidently been con-  
th crushing. The stone contains a little copper  
Homeward Bound reef is recorded in Geological  
No. 20 to have crushed 1,728.50 tons of quartz for  
gold.

Blue (G.M.Ls. 85, 187).—Workings were on a big  
V.N.W. and E.S.E. There is a large amount of  
shallow surface workings, some of it stained with  
opper. 183.25 tons are recorded to have returned  
f gold.

ongan Star (G.M.Ls. 92, 623) two men have been  
getting good stone. The reef is rather a flat one,  
all shafts have been sunk to cut it. The stone often  
copper carbonate. I have been unable to find any  
crushings than those given in the Government  
, where the return from 331.25 tons treated is given

ta mine (G.M.L. 615) has been pretty extensively  
in shaft being sunk about 400 feet on the underlay  
reef, the bottom level of which is about 70 feet below  
he reef is about 3 feet wide, but varies from 1 to  
one carries a good deal of copper, enough to inter-  
de treatment of the battery tailings. Several shafts  
on the *Stray Shot* section of the ground, on which

there is a 5-head battery, the only one at present available in the district. The Government Geologist's report gives the output of the Augusta mine as 5,619.40 tons crushed for 14,057.73 ounces of gold, but I was informed when going over the ground that the output was believed that about 16,000 tons in all had been crushed, much of which was never recorded. Since the end of 1907 to the date the Government Geologist's table is made up, 212.2 tons of ore have been recorded as crushed for a yield of 378.18 ounces of gold.

The reefs of the above auriferous belt are strong, composed of bodies of quartz, and undoubtedly fissure veins. The reputation of having contained the payable ore in short shoots from the appearance of the workings it seemed to me that the reef had been "picked out" by taking only the richest ore, and that it could not properly be said to be in shoots at all. According to the information I received from men who knew the mines where the reef was worked, there is a large amount of low-grade ore in the shallow ground already opened up, and every prospect of the reef was systematically opened up below the water level, and could be profitably worked once there is railway communication from the coast to Marble Bar. The record of the reefs is rather poor as regards value of the ore crushed, and it seemed to me that it could not be said that many of them had ever had a fair trial. The reefs seem very well worth attention from investors. A systematic sampling and assaying of the quartz still in the workings will give valuable information as to the prospects of being able to work the reefs in bulk as low-grade concerns.

The *Franklin* (G.M.Ls. 641, 655) mine is situated about 10 miles south of Marble Bar in laminated dioritic schist composed of coarse grained rough stony ridges. There are two nearly parallel reefs, close to one another, the distance between them being about 100 feet at the shaft workings. They run nearly N. and S. and undulate a little, but what flatly to the west. The reefs are from 2 to 6 feet thick, and would average about 3 feet. They join together both north and south of the shaft workings and perhaps should be considered as one reef with a somewhat long "horse" in it. It is a quartz fissure lode, though lying nearly in the lamination of the schist. It cuts through this in places, shows occasional enclosures of schist, "try," and has good well smoothed walls. Not much work has been done as yet, but two leases are still held and worked. The output to the end of April, 1907, is 189.01 tons crushed for 1,190.01 ounces of fine gold. The outcrop is easily traced a considerable distance north and south from the workings, and is said to carry a fairly long way. It has been sunk upon by a shallow shaft, and the reef rapidly rises into a hill to the south it could be worked by a short crosscut tunnel from the gully which carries the reef north of the shaft and driving south therefrom on the



the lode. The reef is a strong and distinct body of quartz and seems well worth prospecting thoroughly. The stone shows a little copper pyrites at times, and in some of it gold could be seen readily.

The officially recorded output of the Marble Bar district to end of April, 1907, is 9,202.09 tons crushed for 15,517.19oz. fine gold, 170.91oz. fine gold from dollying, and 8.94oz. from alluvial, making a total of 15,697.04 fine ounces. This, however, does not include a large amount of alluvial gold not segregated to the centre where it was produced in the returns from the Goldfield generally, which for the same period gave a total of 6,014.06 fine ounces, and a probably still larger amount which was never reported at all. The Government Geologist's Bulletin No. 20 gives the following table of production of the Marble Bar Reefs to the end of 1904, which, though the gold has not been reduced to fine ounces and so is not absolutely comparable with the statistical return, shows at a glance that he was able to obtain records of both more stone crushed and more gold therefrom than is shown in the latter.

*Summary Table showing the Yield of the Marble Bar Reefs up to the end of 1904.*

Name of Reef	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Augusta ... ..	5,619.40	14,057.73	2.50
Augusta No. 1 South ... ..	66.00	149.60	2.26
Coongan Star ... ..	331.25	598.95	1.80
Excelaior ... ..	Included under Augusta.		
General ... ..	Included under Homeward Bound		
Homeward Bound ... ..	1,728.50	2,420.30	1.40
Ironclad ... ..	2,040.50	1,441.57	.70
Ironclad South ... ..	61.00	24.00	.39
Iron Duke ... ..	40.00	25.70	.64
Keep-it-Dark ... ..	32.50	73.65	2.26
Marble Bar ... ..	11.00	15.70	1.42
Pillendinnie ... ..	1.00	342.00	342.00
Rejected ... ..	Included under Homeward Bound		
Robert Bruce ... ..	112.00	116.92	1.04
Shamrock ... ..	60.25	142.80	2.37
Stray Shot ... ..	Included under Augusta.		
Sundry Claims ... ..	443.80	4,532.29	10.21
Trafalgar ... ..	30.00	90.00	3.00
True Blue ... ..	183.25	310.02	1.69
<b>Total ... ..</b>	<b>10,760.45</b>	<b>24,341.23</b>	<b>2.26</b>

This is an excellent average return, spread over a large number of mines, none of which have been opened up extensively, or to any considerable depth. The reefs show large and strong bodies of quartz and have every indication of being persistent in depth, and

it seems to me that they have been so unsystematically there is no sound foundation for the commonly held belief that gold is in very short shoots. It is doubtless very poor occurrence, but there are very good grounds for thinking that some of these mines could be reopened with profit when workings are improved.

The auriferous dioritic country runs northward from Marble Bar for about 20 miles to Doolena Gorge, and is then replaced by a great granite coastal plain. A narrow strip of it, however, is shown by the Geological map to run eastward from Doolena Gorge for 40 miles, to past Bamboo Creek. This country is also known as Marble Bar for about 10 miles, then turns southward to Warrawoona to Yandicoogina, and thence northward again to Bamboo Creek. It seems to form quite a narrow strip except on the western side, where it probably is connected with a larger greenstone area, part of which is concealed beneath the overlying strata of the Nullagine series. It is noteworthy that at Marble Bar, Warrawoona, and Yandicoogina the rough hilly ranges of the greenstone schists outcrop follow approximately the line of these, which is roughly parallel with their contact with the granite country, strongly suggesting a close connection between the granite and the tilting on edge of the metamorphic schists of the Warrawoona series. I am not yet aware of any other feature is seen in the strip of this country running eastward from Bamboo Creek. It is so at Yandicoogina, and at Lennon's Find further north.

These strips of the greenstone country nearly surround the granite area of granite, part of which has been proved tin-bearing, and which seems to deserve special attention from prospectors.

#### MOOLYELLA DISTRICT.

The Moolyella tinfield lies towards the western end of the granite area just mentioned, about 10 miles from Marble Bar. The workings are mostly alluvial, on level ground from a patch of low granite hills rising out of the general granite plain. The principal leads run northward, but the tin has also been found more or less all round the hills, and the discovery has been extending. Some of the tin ore is found in very shallow workings almost on the outcropping granite, and is doubtless derived from small veins in this. In some of the flats where the surface layer is deeper there are two portions which have been known at the bottom "wash" in well-defined "leads" and the top of the drift, the latter no doubt representing the result of the concentration *in situ* of the tin ore which was at one time carried through a much larger bulk of overlying drift. The deposits represent the concentrations in watercourses at a time when they were cutting their way down into the granite bedrock. A change in conditions caused the valleys to be refilled with

The Moolyella Field is described in *Geological Survey Bulletin No. 15*, with a map which shows the heads of what were the three principal "leads" at the time of the Government Geologist's visit in 1903. It also shows a series of strong quartz reefs and several pegmatite dykes running roughly north and south through the country at the head of the leads. Since then the field has developed considerably, particularly in Berne's Flat and down the Moolyella Creek towards its junction with Brockman's Creek, to the west and north-west of the ground shown in the geological map. Berne's Flat was first worked by dryblowers, who treated the very shallow soil in the watercourses on the granite bedrock and the superficial iron-bearing layer on the flat. They did not, however, go to bedrock in the flat, and so missed the deep lead. This was discovered by McDonald Bros. and Party, who took up nine claims, 200 yards by 100 yards, giving them a length along the lead of 1,800 yards by 100 yards in all. The ground has been found to average about 15 feet in depth, with two feet of payable "wash" on the bottom, the width of the bed being about 30 feet on the average, though often narrower, and sometimes up to 100 feet. The wash is somewhat clayey but puddles fairly freely. It is mostly light material but contains numerous sub-angular stones of quartz, felspar, and granitic vein stuff. The tin oxide is fairly coarse and not very much water worn, but gets finer in grain lower down the lead. The "wash" is raised to surface from numerous windlass shafts and carried to a puddler worked by a horse. This puts through about 20 loads per day of eight hours. The tin got by washing out the puddler is hand-jigged and dressed till clean, when it assays about 72 per cent. metallic tin, and is bagged for shipment, going now to Singapore to be smelted. At the time of our visit McDonald and Party had obtained about 470 tons of black tin from their ground, valued by local buyers at £103 a ton on the ground. Getting to the coast costs £6 a ton, and total expenses to the Singapore Smelting Works were given to me as £13 10s. a ton. The mining and puddling costs were about 25s. per cubic yard of dirt, or equal to the value of 27lbs. of black tin, which is therefore about the minimum yield per yard that is payable. The actual yield has been much higher, this having been a very profitable claim. It is, however, nearly worked out now.

North of McDonald's ground comes that of Prouten and Party, who have two men's ground, or 400 yards by 100 yards. They have the lead at about the same depth as McDonald, and had got 79 tons of tin up to the time of our visit. Cheriton's, Markell's, Collingwood's, and Moore's claims then succeed one another following the lead northward. Two of these parties were working with hand puddlers and cradles. The wash and tin both become lighter towards the lower end of the lead. It seems likely enough that further extensions of the lead to the northward will yet be worked.

In the Huntsman's Creek very little work has been done but there seems some reason for trying to trace it deep ground also.

In the Moolyella Creek the workings have now gone deeper ground in the flats, the upper shallow portions being worked out. The first claim examined was that of another McParty who were working ground 12 feet deep by open workings. The wash was about four feet thick, containing rather fine tin ore, but the bottom of the lead had not been laid bare and was considered highly payable.

Next to this claim comes 10 men's ground held by Muir, and Party, who have the lead at a depth of 24 feet. The wash is about two feet thick and fully 100 feet wide ; tin ore is well grained. It is considered payable, but had not been worked at the time of our visit, being stacked for treatment.

Below this comes McLaren and Party's claim of 100yds. Several shafts have been sunk 25 feet to the bottom and connected by a drive along its course 200 feet long, with crosscuts which show the lead to be 20 to 40 feet thick. McLaren proposes to do as much of his sluicing as possible on the ground, in boxes placed in the main level, stacking the tin ore back in the worked out ground and pumping it to the surface, and was erecting machinery for this purpose at the time of our visit. The ground was very well and systematically worked up for working, and Mr. McLaren estimated that 20 tons of the ton of wash-dirt would pay expenses. A fair amount of fine tin ore could be seen in the wash, which was considered payable. This claim is well out in the flat country near Brockman's Creek. A rather deep water shaft had been sunk near where the lead enters the claim, but I understand that the quantity of water has not proved so large as was hoped for.

Below McLaren's claim a sluicing and dredging system has been applied for in Brockman's Creek, but bores have shown that the lead in the creek to be shallower than the bottom of the lead in McLaren's claim, and there is therefore a likelihood that the dredging system had an outlet which is buried under the flat country and correspond with the existing creek in position. The bottom of Brockman's Creek at this point shows the granite bedrock out strongly, so the deep old channel must presumably be there and the lowest workings on Berne's flat and McParty's leads. Some lines of bores or prospecting shafts are being sunk and would soon show if such a deep lead exists. There is some probability of the shallow leads which have been worked by

unite with one another into a main lead, and the amount of tin already obtained justifies prospecting for this in the belief that it also will contain workable deposits.

At the head of the Moolyella Creek all the small watercourses on the slopes of the granite hill have been worked for tin ore right up to the hilltop, the tin ore obtained being very crystalline and often having veinstuff adhering to it. Numerous veins are seen traversing the granite of albite and quartz with mica and green talc or hydromica. The veins lie very flat as a rule and are not big enough or regular enough to be worked as tin lodes, though some of them are rich enough in tin ore to be well worth working if they were a little larger. Probably in course of time some will be found big enough to work. The veins are not numerous enough to form a "stockwork," but are sufficiently plentiful to have yielded a large amount of ore to the alluvial deposits by their disintegration under weathering agencies.

On the opposite side of the hill near the head of Berne's flat there are several more veins of the same sort, one of which is known as Eley's lode. One of the veins is at times as much as 3 feet wide, mostly felspar and quartz with coarse crystalline tin oxide—one vertical vein about 10 inches wide was worked to a depth of 5 or 6 feet, the ore being dollied. The veins are irregular in size and occurrence and do not appear to be true fissure lodes, but rather "segregation veins," and are not very promising from a mining point of view. They are important more as showing the nature of the occurrence of the tin ore in the bedrock than as workable propositions themselves. It is very possible, however, that larger and better ones, though of this type, may prove well worth opening as lode mines. The veinstuff is quite similar to Geological Museum specimen No. 5397, of which an analysis is given on page 12 of *Geological Survey Bulletin* No. 15.

About two miles south from the "Mud Springs" Government Well there is a big outcrop of very fine lode tin ore in a large pegmatitic vein, known as Atkins' lode, of quartz, felspar (orthoclase and albite) and greenish mica, running west-north-west and east-south-east. The lode is up to 12 feet wide, and some parts of the outcrop are nearly all quartz, while others are mostly felspar. Where the tin ore is found it is mostly in a matrix of greisen (quartz and mica), but some of the felspar also carries cassiterite. A shallow cut had been made into the lode at this point, several holes having been drilled and fired, but the place was not well cleared out so that a good view could be obtained. Beautiful specimens of tin ore were easily obtainable, the stuff being very rich, but much more work is required before it can be seen what is the

extent of the patch of ore. It is very well worth opening thoroughly and there seems a good chance that a pay of ore exists of good size for working. A sample of the ore analysed in the Geological Survey Laboratory yielded 13.3 per cent of metallic tin, and some of the best ore is a good deal better than this. The vein, however, is rather a pegmatite or segregate than a true lode.

A short distance to the north of Atkins' lode I noticed a large pegmatite vein showing a little tin ore, on which no work has been done. Still further north close to Mallet's fence there are some well-defined pegmatitic veins of quartz, pinkish felspar and mica carrying a large amount of magnetite, which is easily mistaken for tin ore. A good deal of this magnetite is lying about the surface of the ground in the vicinity of the lode.

Another lode, known as Martin's, somewhat similar to Atkins', has lately been found near the head of Berne's flat to the north from the township there. It seems to be about 4 feet thick and is well exposed by the little work as yet done on it, and contains a fair tin ore. Its course seems to be about north-north-west to south-south-west. Another vein lying rather flatly to the south-east of this find has been found by dry-blowers and contains very good tin ore in it has been found by dry-blowers at a distance east of this find. This ore is in a matrix of granite like that of the ore shoot in Atkins' lode, and the discovery is well worth prospecting further.

Atkins' and Martin's "lodes" may prove to be important reef propositions, and their discovery gives hope that tin for tin may become established in the Moolyella district. At present there are no means of crushing the stone containing the tin oxide. Crushing and dressing machinery will have to be put in for this before the lodes can be profitably worked.

The yield of tin ore from the Moolyella field is recorded as—

To the end of 1906	...	Stream tin	1,705.19 tons	valued at	...
"	"	April, 1907	...	"	"
Total	...	...	"	"	1,917.09

There were said to be about 500 people on the Moolyella at the time of our visit; and though the shallow ground at the older leads has been worked out pretty well there is still a lot of work to be done in the deeper ground, and the field will therefore maintain an output of alluvial tin ore for two or three years.



even if no new leads are found. The discovery of Martin's lodes, some distance from the known leads, rests that the field must be a good deal more extensive than present workings, and further alluvial finds are to be expected as prospecting goes on. There is also a certain amount of lode mining becoming an established industry.

#### WARRAWOONA.

The country of dioritic and metamorphic schist country of the Warrawoona Bar is found continuing south and south-west through Wyman's Well (or Salgash) to Warrawoona, where rugged steep serrated ridges. This district has been described, with illustrative maps, by the Government Geologist in his *Bulletin* No. 20, to which reference should be made. The strata are of sedimentary origin, comprising highly crystalline quartzites, conglomerates and schists, while others are gneisses, usually rendered highly schistose by the pressure and stresses to which they have been subjected. The country on the northern side of the hills has apparently to some extent in these compressive and shearing is somewhat foliated close to its junction with the schist to their lamination.

One of the Warrawoona mines which was visited by the Government Geologist (G.M.L. 627), formerly known as the "Klondyke Queen," under which latter name it is described in the Geologist's report. The workings are above and below the lode on the north-westerly on the course of the lode, which consists of somewhat lenticular bodies of quartz enclosed in the schist, but nevertheless in my opinion of sedimentary mode of origin. There seem to be two or three parallel veins lying more or less *en echelon* along the general strike of the lode. Above the tunnel the reef has been stoped out to a height of 80 feet or so in height, and it has also been worked by adit to water level about 80 feet below the tunnel. The reef has been worked for over 300 feet in length. This has been a small reef, the returns quoted by the Government Geologist for the year ended 1904, 731.75 tons crushed for 4,784.40 ounces of gold at the rate of 6.53 ounces per ton. At the time of my visit the reef was again being done on it. From what I could learn it seemed likely to be very persistent in depth, and I am of opinion that the values will also be found to continue satisfactory. It is not usually a large reef, but of considerable size, and it is a great pity that it has not been worked to depth.

The Government Geologist's map shows a long belt of reefs extending north-westerly for a distance of six miles and width of 20

chains, and his descriptions show that many of the reefs are of fair size and that they have given very good crushing results. At the time of our visit there were only 16 men working on the reefs, but some of them were on very good gold, and there is no doubt that in a more favourably situated part of the State for mining conditions this field would be supporting a large number of men. The following table from the Government Geologist's report shows the output from the various reefs to end of 1904:—

*Synoptical Table showing the yield of the Warrawoona field to the end of 1904.*

Name of Reef.	Ore crushed.	Gold therefrom.	Per cent.
	tons.	ozs.	
Admiral Dewey ... ..	8.45	4.55	
Bow Bells ... ..	483.70	855.69	
Bow Bells Block No. 1 ...	12.00	10.50	
Britannia ... ..	19.00	28.70	
Brought to Light ... ..	8.75	7.96	
Carnoustie ... ..	45.40	178.11	
Chance ... ..	4.00	8.35	
Criterion ... ..	12.20	7.80	
Cuban ... ..	51.30	215.41	
Cutty Sark ... ..	36.05	59.10	
Dead Camel ... ..	18.75	63.50	
Gauntlet ... ..	1,289.30	3,693.55	
Gift ... ..	44.05	73.50	
Golden Gate ... ..	59.45	124.50	
Golden Gauntlet ... ..	3.00	4.60	
Imperialist ... ..	695.75	810.58	
Juneau ... ..	13.85	15.33	
Klondyke ... ..	731.75	4,784.40	
Klondyke Block ... ..	37.00	764.00	
Klondyke Boulder ... ..	1,016.16	2,450.93	
Klondyke No. 1 West ...	43.00	189.67	
Klondyke Queen ... ..	9.90	13.75	
Nelson ... ..	1.25	5.29	
Princept ... ..	2.15	5.00	
Princess of Alaska ...	40.00	70.61	
Rangatira ... ..	8.50	5.15	
Reward Claim 94 ... ..	351.55	1,037.89	
St. George ... ..	20.00	124.00	
Tom Thumb ... ..	36.55	164.66	
Treble Event ... ..	3.25	4.00	
Wheel of Fortune ... ..	206.35	249.95	
Sundry Claims ... ..	387.60	{ 773.29 *50.00 †433.30 ‡6.56 }	
Cyaniding ... ..	...	...	
Total ... ..	5,700.01	17,294.18	

\* Alluvial. † Specimens. ‡ Nine tons of sands.

The latest official statistics to end of 1904 show 5,835.31 tons crushed, for a yield of 14,707.35 fine ounces, 335.73 fine ounces from specimens dollied, and 44.30 fine ounces from alluvial. Since the end of 1904 the following returns have been officially recorded:—

	1905.				1906.				1907, to 30th April.				Grand Total to 30th April, 1907.			
	Ore treated.	Gold therefrom.	Dollied and Specimens.	Ore treated.	Fine ozs.	Ore treated.	Gold therefrom.	Dollied and Specimens.	Ore treated.	Fine ozs.	Ore treated.	Gold therefrom.	Alluvial.	Fine ozs.	Ore treated.	Gold therefrom.
Total to end of 1904	Tons.	Fine ozs.		Tons.	Fine ozs.	Tons.	Fine ozs.		Tons.	Fine ozs.	Tons.	Fine ozs.	Fine ozs.		Tons.	Fine ozs.
483, 505—British Exploration of Australia	1,253.00	744.17	..	160.00	358.64	..	..	..	..	..	..	..	44.30	335.73	5,835.31	14,707.35
604, Klondyke Boulder	26.00	18.85	..	39.64	46.30	..	..	..	..	..	..	..	..	..	..	..
627, Klondyke Queen	..	..	..	42.75	95.25	..	..	..	..	..	..	..	..	..	..	..
Sundry Claims	41.45	82.53	..	57.94	158.48	..	..	..	..	..	..	..	..	..	..	..
	1,320.45	845.55	..	300.33	658.73	..	..	..	..	..	..	..	..	2.42	1,620.78	1,564.28
Total	..	..	..	..	..	..	..	..	..	..	..	..	44.30	338.15	7,456.09	10,211.63

This is a district which can be commended to the prospectors when the country becomes opened up so that supplies can be got at reasonable rates. At present firewood is sold from £2 to £2 5s. per cord, and mining timber often up to 10s. per lineal foot. The Bow Bell's 10-head battery crushes for 10s. at 27s. 6d. a ton, without cyaniding. Unless very good results are obtained the prospectors have found that they cannot make money from these mines, but if conditions were improved by the construction of a railway from the coast there is every reason to believe that Warrawoona would become a highly payable field, and support a large population.

#### YANDICOOGINA.

The Warrawoona range of auriferous hills extends east-south-easterly to Yandicoogina. The road, however, does not follow the range on to the granite plain lying north of it, but goes to Yandicoogina over the flat grassy country at the foot of the range. From Marble Bar to Yandicoogina the road also passes most of the same flat well-grassed country, often showing small tin-bearing veins in the granite which encourage hopes that tin can be found. The granite is penetrated by occasional dykes of diorite. I did not visit Mt. Edgar, but the Geological map shows it to be of the same metamorphic and dioritic schist formation, and the similarity of its structure to that of the Wodgina District seems to attract attention being given to it by prospectors in search of tin.

The gold mines at Yandicoogina were all abandoned before my visit, and I had no time to make any examination of them. They are fully described, with a geological map, in Bulletin No. 10 of the Geological Survey. From this it appears that the tin is found in a narrow belt of dioritic and metamorphic schists of the Warrawoona series running north-easterly roughly parallel to the granite, and overlaid to the east by beds of the same formation. The country is hilly, being a continuation of the Warrawoona seen at Warrawoona.

The following table is taken from the Geological Survey Bulletin 15, showing the names and recorded returns of the Yandicoogina reefs:—

*Synoptical Table showing the Yield of the Yandicoogina Reefs.*

Name of Reef.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Aunt Sally ... ..	27·00	21·00	·78
Black Shepherd ... ..	611·05	1,955·29	3·20
Eastern ... ..	665·85	777·55	1·17
Granite ... ..	35·00	92·50	2·64
Harp of Frin ... ..	22·50	11·55	·51
Invincible ... ..	13·40	701·00	52·31
Jupiter ... ..	113·50	588·70	5·17
Lady Adelaide ... ..	61·25	88·30	1·44
Lone Hand ... ..	16·00	28·30	1·45
Trilby ... ..	66·00	207·50	3·14
Uncle Tom ... ..	450·05	1,239·91	2·64
Zingara ... ..	8·40	6·80	·80
Sundry Claims ... ..	72·75	56·10	·77
Total ... ..	2,162·75	5,767·50	2·66
Tailings cyanided at Lady Adelaide Battery ...	(700 tons)	325·00	...
Total ... ..	2,162·75	6,092·50	2·81

With this excellent record it seems very strange that the mines should have been abandoned. The reefs seem from the Government Geologist's description to be very similar to those at Warrawoona.

*Lennon's Find.*—My visit to the Yandicoogina district was to see a new find made by Messrs. Lennon, Doherty, and party, about eight miles further north in the same range of schist hills skirting the granite, and about 10 miles south-south-east from Mt. Edgar. The hills are rugged ridges of schist running parallel with the strike of the strata, which is here about north 55 degrees east. A short distance up the hills from their foot on the north-western side a strong and well-defined lode has been found by the prospectors and traced for about two miles, lying conformably with the foliation of the schist country, but seemingly a distinct fissure vein. Its outcrop is easily traceable, sometimes forming outstanding masses of quartz and silicified country often stained with green carbonate of copper, at other times showing as oxide of iron gossan. The outcrop had been very little cut into at the time I saw it, but the actual lode itself seemed to me to be rather small, though the country on each side of it was often silicified and charged with metallic minerals. I

think, however, that it will generally be of workable width when opened up.

Going northward along the outcrop I visited first Patrick lease (M.L. 137—6 acres), on which the lode is about 12 to 15 inches of ore being seen in a small cut on the surface. A sample of this ore taken for examination gave the following analysis:—

*Geological Survey Laboratory Assay No. 3373.*

Copper .. ..	14.61 per cent.
Lead .. ..	.39 "
Zinc .. ..	16.33 "
Silver .. ..	23oz. 3dwt. 12grs. per ton
Gold .. ..	0oz. 0dwt. 17grs. per ton

Passing through the St. Patrick ground to the north the lode vein has hardly been scratched, and is small, apparently from 12 to 18 inches wide. I took a few random samples while going, which contained:—

*Geological Survey Laboratory Assay No. 3376.*

Copper .. ..	17.20 per cent.
Lead .. ..	1.66 "
Zinc .. ..	6.93 "
Silver .. ..	20oz. 18dwt. 13grs. per ton
Gold .. ..	0oz. 0dwt. 13grs. "

Another sample taken mostly from a cut on the lode boundary between the Prospecting Area and the St. Patrick lease gave:—

*Geological Survey Laboratory Assay No. 3375.*

Copper .. ..	5.33 per cent.
Lead .. ..	2.79 "
Zinc .. ..	5.52 "
Silver .. ..	4oz. 13dwt. 19grs. per ton
Gold .. ..	0oz. 0dwt. 17grs. "

Still following the lode north-easterly through the Prospecting area (P.A. 151—18 acres) the outcrop appears to be copper, but is much larger, forming masses of quartz up to 10 feet wide. A shaft has been sunk about 15 feet, the lode is from four or six feet wide in it, without the footwall being seen. It dips about one in three to the south-east. A sample of the ore taken from the shaft gave on analysis:—

*Geological Survey Laboratory Assay No. 3374.*

Copper .. ..	6.68 per cent.
Lead .. ..	3.85 "
Zinc .. ..	4.45 "
Silver .. ..	2oz. 6dwt. 20grs. per ton
Gold .. ..	0oz. 0dwt. 17grs. "



Another sample from a vein of baryte two feet wide in a large outcrop eight to ten feet wide near the north-east boundary of the prospecting area gave on analysis:—

*Geological Survey Laboratory Assay No. 3378.*

Copper	..	..	..	6.40	per cent.
Lead	..	..	..	5.55	"
Zinc	..	..	..	8.37	"
Silver	..	..	12oz.	1dwt. 11grs.	per ton.
Gold	..	..	0oz.	0dwt. 17grs.	"

This vein was in a mass of quartz and silicified schist much stained with green carbonate of copper.

In the *Ribbon Lease* (M.L. 143—6 acres) about a mile further north there are 12 to 24 inches of lode stuff in a much wider body of silicified schist much stained with malachite. A sample from here gave on analysis:—

*Geological Survey Laboratory Assay No. 3377.*

Copper	..	..	..	6.01	per cent.
Lead	..	..	..	.36	"
Zinc	..	..	..	.86	"
Silver	..	..	5oz.	8dwt. 4grs.	per ton.
Gold	..	..	0oz.	0dwt. 9grs.	"

I did not see the south end of the line of reef (M.L. 149—12 acres), but obtained a bag full of the ore from there which proved to contain a good deal of sulphate of lead in baryte and gave the following analysis:—

*Geological Survey Laboratory Assay No. 3379.*

Copper	..	..	..	Nil.	
Lead	..	..	..	13.89	per cent.
Zinc	..	..	..	.37	"
Silver	..	..	39oz.	14dwt. 8grs.	per ton.
Gold	..	..	0oz.	1dwt. 15grs.	"

The Government Mineralogist and Assayer in reporting these results says, "The minerals in these samples are so intimately commingled that some are difficult of exact determination. The copper appears to exist wholly as malachite with possibly a little cuprite and chrysocolla; the lead in 3379 is wholly present as the sulphate (anglesite), and probably most of that present in the other samples is in the same form though a little carbonate (cerussite) may also be present. The zinc occurs mainly if not wholly as silicate (hemimorphite). The principal gangue minerals are quartz, limonite, calcite, and barytes in varying proportions. 3379 contains about 20 per cent. anglesite, 17 per cent. quartz, and 62 per cent. barytes; calcite and limonite being almost absent. In the other six samples barytes is less abundant; calcite, limonite and quartz more so. The silica content appears to be uniformly small."

As these samples were taken from the outcrop without attempt at picking out the more valuable ore, they are not so high in metallic contents as the ore would be that would be sent out for shipment in the course of actual working. The results for copper and silver on the whole are very encouraging, though the presence of zinc is detrimental. The value of the lode cannot be gauged until some work has been done to enable it to be examined to some little depth below the outcrop, and if possible below the oxidised material altogether, but present indications seem to warrant energetic prospecting, there being apparently very good chances of success.

The following assays of ore from this lode have all been made in the Geological Survey Laboratory.

Sample sent by Messrs. Lennon and Doherty through the Department of Mines, April, 1907:—

*Geological Survey Laboratory Assay No. 3065.*

Copper	..	..	..	1.10	per cent.
Lead	..	..	..	2.39	"
Silver	..	..	6oz.	1dwt.	23grs. per ton
Gold	..	..	0oz.	0dwt.	13grs. "

*Geological Survey Laboratory Assay No. 3087.*

Copper	..	..	..	12.81	per cent.
Lead	..	..	..	2.57	"
Silver	..	..	21oz.	2dwt.	12grs. per ton
Gold	..	..	0oz.	0dwt.	13grs. "

Sample said to be from about seven tons, taken by the miners daily while the ore was being raised in sinking a shaft 100 feet deep, crushed, passed through sieves, and thoroughly mixed before forwarding it:—

*Geological Survey Laboratory Assay No. 3507.*

Copper	..	..	..	18.23	per cent.
Lead	..	..	..	0.76	"
Silver	..	..	22oz.	12dwt.	6grs. per ton
Gold	..	..	0oz.	1dwt.	6grs. "

#### NULLAGINE DISTRICT.

The road from Warrawoona runs south-south-west across an extensive grassy plain of granite, on which the Corunna Downs Station, until it strikes the hilly country again near Carbarra Well. From this to Spinaway's Well the road lies over rather rough hilly country, partly belonging to the Warrawoona series of rocks but mostly lavas and conglomerates of the Nullagine series. From Spinaway's Well to Nullagine the road traverses easier country but still somewhat hilly, and according to the geological map for the most part goes just a little to the north of the boundary between the Nullagine beds and the mu-

stones, and conglomerates of the Mosquito Creek series. That of granite is, however, seen as well, and bars of jasperite, possibly of the Warrawoona series.

Geological structure of the Nullagine district is fully described in maps and sections, in the Government Geologist's report No. 20 of the Geological Survey. His general map of the Goldfield in Bulletin No. 23 should also be consulted, to show the areas occupied by the various formations. The Nullagine series consists of slates and fine conglomerates to which is given the name of the Mosquito Creek beds is there seen to be a large stretch of country eastward from Nullagine to beyond the Dampier River, and northward nearly to Yandicoogina. There is some evidence that they are younger than the Warrawoona series of rocks, but older than the great granite formation, which has intruded through them in many places. They are also intersected by several large gabbro and diabase dykes. The strata are inclined at fairly high angles, having been subjected to considerable crumpling, and are overlaid unconformably, to the Nullagine, by the comparatively flat-lying Nullagine beds. The Mosquito Creek beds are of economic importance as they contain numerous reefs which have been the mainstay of the Nullagine district.

*Gold.*—There has been a very considerable amount of gold obtained round Nullagine, derived from the wearing of the auriferous reefs of the Mosquito Creek beds and the conglomerates of the Nullagine series. There are a few prospectors still about the field, but the output of alluvial gold is not very small.

*Auriferous Reefs.*—These mostly lie to the east of the Nullagine, where there seems to be an auriferous belt running roughly, comprising a group of roughly parallel quartz reefs more or less north-east and south-west. None of these are at present operated though a good deal of work has been done on them; they have a very creditable record of value of stone crushed. The principal ones were the *Victory* group, about a mile south-east of Nullagine township. Several shafts have been put down on them, the deepest being said to be 150 feet deep, but most of the others are less than 70 feet. The *Victory* reef is rather small, averaging 200 feet in width. Parts of it were very rich, but the gold is not very abundant. There is said to be still a lot of stone in these mines which would yield 12 to 15 dwt. of gold per ton, but this would not be worth mining, with battery charges of 35s. a ton and transport 10s. a ton. The *Victory* reef has been traced for a mile. Less than a mile north-east from the *Victory* and on the west side of a rough range of gabbro hills and the Kadgeburt

Creek are the workings of the old *Great Eastern* mine. Here was a shaft about 100 feet deep, now fallen in. A large vein seen running north-easterly, the outcrop showing 10 or 12 feet width of quartz standing out boldly as a small rocky ridge, but about two feet of the hanging wall or eastern side seem to have been worked, so far as can be seen at surface. The country to the east and east from this old mine contains numerous reefs and on which some work has been done, and auriferous country followed out towards the Mosquito Creek mines. The following table of the yield of the Nullagine quartz reefs is taken from Geological Survey Bulletin No. 20.

*Synoptical Table showing the Yield of the Nullagine Reefs up to the end of 1904.*

Name of Reef.	Ore crushed.	Gold therefrom.	Reef
	tons.	ozs.	
Day Dawn ... ..	266'00	702'70	
Fisher's Reward ... ..	20'00	56'60	
Golden Eagle ... ..	105'95	492'95	
Great Eastern ... ..	170'00	202'75	
Great Eastern Extended ... ..	190'00	224'40	
Promise ... ..	30'00	90'00	
Sunrise No. 1. ... ..	28'00	14'00	
Victory ... ..	121'00	421'10	
Victory East Extended ... ..	285'00	1,229'80	
Victory Extended ... ..	22'00	63'00	
Total ... ..	1,237'95	3,497'30	

The average yield is seen to be very good, and would be better if the gold produced by cyaniding the tailings could be added to it. 2,800 tons of tailings were cyanided in 1902-3 for 10 ounces of gold, or .58 ozs. per ton, but it is impossible to know how much of this came from the tailings from the local reefs, how much from crushings from outside districts, and how much from conglomerate tailings. It is clear that only a small amount of stone was worth raising, and as this was in smallish patches, it took a good deal of finding, the prospectors were only able to get out a small tonnage from each mine. It was impossible to get a full view of the underground workings when I visited these mines, but from the information obtained on the spot and the recorded results it seems probable that many of the reefs could be worked profitably. The costs of mining and crushing were cheapened to something like the prevailing in the southern goldfields. If a much lower grade of ore could be crushed profitably it is quite possible that the reproach of patchiness now attaching to these reefs might be removed.

*ferous Conglomerates.*—These are the most interesting deposits in the Nullagine district, and are worthy of notice, not only on account of their marked similarity to the "banket" reefs of Johannesburg, South Africa, but also of the very wide spread distribution of the Nullagine beds, they form a stratum, over the Pilbara goldfields. It has been noted that gold has been found at the Just-in-Time near Marble Bar, in a similar conglomerate, and there is some evidence that its occurrence in such beds of this form is not merely a fortuitous local one, but is liable to be anywhere in the areas occupied by the Nullagine beds where composed of the detritus of older auriferous rocks.

The conglomerates at Nullagine are fully described, with several photographs and maps, in the Government Geologist's Bulletin No. 10. No work has been done on these leases since his visit, and it is necessary to repeat the details given by him, for which his report should be referred to. His topographical map, Plate II., from the plans of the Nullagine Conglomerates Gold Mines, is very worth close study, showing the distribution and relative value of the workings over the area on which the auriferous conglomerate has been found. The surface of the country is here composed of very rounded, often dome-like, hills, carved by erosion from a mass of nearly horizontal but somewhat curved and crumpled beds of grits and conglomerates of the Nullagine series. The workings can all be included in a quadrilateral area of about 160 acres, with base or south side extending eastward from the Grant's Hill workings about three-quarters of a mile, north side, parallel to the base one-quarter of a mile, and distance between these sides about one mile. In this area ten or more openings have been made in the auriferous boulder bed, from which crushings have been taken and are shown in detail in the table attached to the report in the Geological Survey Bulletin No. 20. From this we see that 5,167 tons together were crushed which returned 3,217.29 ounces of gold, or a general average of  $12\frac{1}{2}$  dwts. per ton. Individual crushings, however, show as high as 28 dwts. per ton and down to 2.4 dwts. per ton, the latter being the average figure for the last 777 tons crushed in 1903 from the principal workings on Grant's Hill, after which work was suspended. These workings, however, produced over 3,433 tons of stone, which yielded 1,780.24 ozs. of gold, or an average rate of 10.4 dwts. per ton. The next most important workings, on the Success lease, turned out 643 tons yielding 6,430 ozs., equal to a general average of nearly 18 dwts. per ton, and in this instance also the last year's work gave poor results, 100 tons crushed in 1901 returning only 33 ozs. of gold, or 6.6 dwts.

The openings, as is easily seen from the map in Bulletin No. 20, are scattered over the proved auriferous area, and in the

absence of good reasons to the contrary the average return from them would presumably very fairly represent the average value of the auriferous deposit in that area. It is therefore important to take notice from the table of returns that good values have been obtained from crushings at several widely separated openings, and that the falling off in value of the last stuff crushed from the Success Grant's Hill mines does not necessarily mean that the deposit as a whole has been proved to diminish in value as it is worked. It rather seems to indicate uneven distribution of values in the deposit which would be averaged if it were worked on a more extensive scale from several different openings. In the present state of the available evidence I see no strong reason for fearing that the general average return from the deposit will be greatly less than that of the 5,000 ton sample that has been actually milled.

Should this be correct, it is evident from inspection of the workings that only a very small part of the auriferous deposit has yet been touched and that there is a very large tonnage of ore waiting to be extracted within the quadrilateral area above mentioned, to not to speak of the extensions outside that area which have yet been tested. Each foot in thickness of the deposit would contain over 2,000 tons of crushing dirt per acre, and as the auriferous layer has been proved to be often four and even six feet thick, it is evident that there is a very large tonnage available, and that the successful development of these conglomerate mines is of the greatest importance not only to the district but to the State also.

My visit to these mines was a very short one, and they were not being worked, so it was impossible to form any reliable opinion from personal observation as to the values of the ore in sight. The Success Grant's Hill workings, which were the only ones visited by me, consist of a layer of conglomerate that has been worked is four to six feet thick and lies fairly flat on the whole, but is so much curved by local movements that it is very undulating, and rises and dips of 10 to 20 degrees are constantly being met with which considerably hamper systematic working. The conglomerate is made up of boulders and gravel, the boulders often being as large as a man's head or even larger, and usually smaller. They are composed of hard jasper, hard conglomerate, quartz, and other hard rocks derived mostly from the underlying strata of the Mosquito Creek series. Veins of iron ore are common, and much of the material cementing the strata together is ferruginous. In some of the deeper workings it is evident that and probably the iron oxide in the outcrop rocks is largely the result of weathering of pyrites. The gold is mainly in the cemented material, and is rugged and crystalline, being therefore evidently deposited from solutions traversing the old gravel layer. The ore is not simply alluvial gold in an old cemented gravel. The ore



be similar in all essential respects to that of the "banket" in the Witwatersrand field in South Africa. The impregnated conglomerate with gold is rather probably quite local, but considering the great distance over which the South African deposits have been proved to be auriferous, there is reason to hope these conglomerates also may prove to carry gold over large areas. It is to be remembered that the Nullagine series contains extensive and very extensive beds of lavas, pointing to widespread continued volcanic activity during their formation, and this doubtless accompanied with much fracturing of the earth's crust and hydro-thermal action, which might reasonably be supposed favourable, in accordance with the most generally accepted theory of ore formation, for the impregnation of permeable gravels with auriferous solutions and gold.

A conglomerate raised from the mines was taken by tram to a 20-head stamp battery and there crushed, but the battery has since been removed. The methods of raising and forwarding the ore to the mill seemed to me capable of very considerable improvement. Work was resumed, and cheap handling and crushing would be of the greatest importance in making the mines profitable. It is worth suggesting that some experiments should be made on the harder conglomerate to see if it could not be disintegrated by crushing all the big hard stones. If these could be freed from the cementing material adhering to them by a process of attrition revolving disintegrating cylinders the quantity of stuff requiring crushing and amalgamation could be greatly reduced, and as the harder boulders apparently contain no gold this would have to be recommended. It did not seem to me that the cementing was too firm for some such treatment.

The working of these conglomerates did not prove profitable, and the owners ceased operations pending such improvement of conditions as would enable them to resume them with a reasonable expectation of success. It is clear from the results obtained that there is here a very important low-grade prospect. But though enough has been done to show that it deserves the most serious consideration, it appears to me that before again attempting to work it on the large scale which its importance warrants it would be judicious to carry out some systematic prospecting in the auriferous area, where the deposit is more deeply buried in order to get a more accurate estimate of its average value, to determine more exactly its real shape, and so obtain data from which to adapt the scheme of mining to best advantage, and to ascertain, if possible, under what conditions there is the best expectation of the richer portions of the ore. It is rather probable that the nature of the deposit may favour the concentration of gold in certain parts of it, for example, in the bottom of the synclines

(trough-like or basin-shaped bends), and that faults dipping and cutting the strata may exercise considerable influence on the deposition of the gold. A certain amount of valuable information could be got rapidly by diamond-drill borings, but as the faults are not as a rule deeply buried it would be preferable in the first instance to adopt the slower and more expensive, but much more satisfactory method of sinking prospecting shafts and driving therefrom. These would be of service later on as mullock shafts for sending material to the filling for the stopes and air shafts for ventilation of the workings, and would enable bulk tests to be obtained from various parts of the deposit, and the conditions of occurrence of the best ore to be closely studied. A comparatively small expenditure in this preliminary work would enable the average value of the ore to be very satisfactorily proved, so that extensive operations could be begun with reasonable certainty as to tonnage and value that would be

Should the workings of these auriferous conglomerates be commercially successful there will be a wide field for prospecting by drilling in the very extensive areas of the Nullagine beds scattered over the Pilbara and West Pilbara Goldfields, especially where the conglomerates rest upon the proved older rocks of the Warrawoona and Mosquito Creek formations. Where the base of the Nullagine beds is cut into by erosion at surface, alluvial gold in the gullies traversing them will usually afford proof of their auriferous nature, but in many places the basal beds do not appear at surface, and boring will be the easiest method of testing them.

*Diamonds.*—The occurrence of diamonds in the Nullagine conglomerates is referred to fully in the Geographical Survey No. 20. The stones are small, but the discoveries are quite authenticated. Prospectors working alluvial detritus from the conglomerate beds throughout the goldfield should therefore have a sharp look out for diamonds as well as for gold.

#### MIDDLE CREEK—20-MILE SANDY—AND MOSQUITO CREEK DISTRICTS

Auriferous reefs in the sedimentary beds of the Mosquito Creek formation of the Geological Survey are found commonly from the east from Nullagine, but few leases have been taken up until the Middle Creek group is reached, about 12 miles from Nullagine from which centre eastward to Mosquito Creek mines have been opened on numerous reefs at short distances apart. The time at disposal during our visit only allowed a very flying look at some of the more prominent mines, without any chance of more than a most cursory examination of them, so the following notes on these districts are necessarily very incomplete. The district has, however, been examined at more leisure by the Government Geological Survey, and reports and maps have been published in Geological Survey

which account of the district my notes may be regarded as elementary.

*Spec (164L).*—No work had been done in this mine for when we visited it, but it was thought worth looking at of the large quantity of stibnite carried by the reef. It is said to be down 70 feet. There are two parallel reefs, 100 feet wide, some seven or eight feet apart, running north-south. Mr. Kelly, the manager of the 20-Mile Sandy State mine, informed me that the lode could be traced for more than 100 feet and that there had been several crushings from it, which would carry good values in gold. One crushing of quartz, fairly free of stibnite, returned about 2oz. gold per ton, but two others, containing a good deal of stibnite, gave bad milling results. One crushing returned 35dwts. gold per ton by amalgamation on the battery plates, and the other showed 35dwts. in the tailings, and another gave 12dwts. The plates and assayed 25dwts in the tailings. The ore at the surface at the shaft is strongly charged with stibnite oxide of antimony, and a lot of fairly pure solid antimony can be picked out which would be worth treatment for this metal could be cheaply exported. Under present circumstances, however, and only a detriment to the recovery of the gold in the ore, I took a sample of the cleaner antimonial ore from the reef which was found on assay by the Government Mineralogist at Perth to contain 37.30 per cent. antimony, gold 3oz. 10dwts. per ton, and silver, 2dwts. 4grs. per ton. The market value of antimony ore has lately fallen heavily, from over £20 per ton per cent. ore, in May last, to £10 per ton at the end of the month. At the latter rate the gross value of ore of the above assay would be about £19 a ton—cartage to Port Hedland, however, costs 2s. per ton, or with freight to Fremantle, £19 a ton, so it is not at all profitable at ore of the above excellent value cannot be exported at present.

*Spec (106L).*—On this lease there are two strong quartz reefs but very distinctly, running north-north-easterly and dipping south-east about 65 degrees. The main reef is traceable for over 1,200 feet in length, the outcrop often standing boldly, three feet to 12 feet wide. Considerable work has been done on this reef, and the mine has been provided with steam machinery, poppet heads, and a 10-head battery with cyanide tanks, and another 5-head battery on the ground but not erected. It is estimated that the whole of the mining development and maintenance has been paid for out of the produce of the mine. The shaft is a vertical one 180 feet deep, and a bottom level has been run out along the reef at 160 feet. In this the lode is up to 10 feet in width between its walls, but much of this is soft multerial. There is a big body of quartz, but poor at this

point, and the drive was being pushed on to the southward under the good ore shoot worked in the shallower level. The ground proved to be heavy and treacherous, the slate just below the water-level, though doubtless it will be of great depth, and required much timber. As the round timber work was costing 1s. per lineal foot delivered on the mine, this was a heavy expense. There is another shaft on the reef, the shoot of gold. It is 110 feet deep on the underlay, and a new one has been sunk another 50 feet. The reef has been stoped in places three feet to five feet wide, only a portion of the whole "face" being taken. It lies parallel to the stratification of the slate country, but is nevertheless in my opinion without a true fissure reef, the well-smoothed walls, frequent occurrence of crushed and squeezed "mullock" between them, and the fact that the slate in the quartz all going to prove this very clearly. From this mine to end of April, 1907, have been 3,333 tons of ore crushed for 4,193.63 ounces of fine gold. The battery has done much service to other mines in the district, crushing for others when required.

When visiting the Barton mine Mr. O'Brien, one of the owners, showed us some very nice copper ore from the Little River. The lode is said to be up to 15 feet in width, and traces for a considerable distance. The samples shown contained some fine oxide of copper ore fit for export, if the district were rendered more accessible.

*All Nations (G.M.L. 166L).*—A very considerable amount of work has been done on this reef, but the old workings, a shaft 60 feet deep, are now inaccessible. The reef strikes about 45 deg. east. Geological Survey Bulletin No. 15 records 4,193.63 tons of stone crushed for 868.11 ozs. of gold to end of 1903, and is informed on the ground that about 1,000 tons in all had been crushed for a yield of over 2 ozs. per ton. The present owners are sinking a new shaft 200 feet deep to reopen this mine, and are receiving assistance from the Government in this work at the rate of £1 up to from £1 to £2 5s. a foot, according to the depth.

*Little Wonder (136L) and Eureka (147L).*—These mines are on another reef running about west-north-west and east, and have been worked somewhat extensively, but with little machinery. The Little Wonder workings are down to the level, and a winze has been sunk 30 feet deeper. Water is pumped at about 174 feet, the influx into the winze being said to be 100 gallons per hour. The lode appeared to me to be a more extensive affair than the somewhat irregular veins and quartz that have been mined, being apparently a wide "formation" between main walls 20 to 40 feet apart.

There are several other smoothed and striated faces running in various directions and differing much in quartz has been formed along them, and in irregular about the shattered mass of country enclosed between hills. The prospectors have laboriously followed the veins of quartz, as was doubtless the best policy in the early days of the mine, but now that the nature of the ore is visible it seems more advisable to drive boldly along the "formation," with frequent crosscuts from main wall, so as to open up the bodies of ore in a way that will pay for cheap mining. At present a very great deal of hand-labor is required underground on account of the irregular shape of the ore bodies. Some very rich ore has been got from this mine, and has returned as much as 130zs. per ton. Mr. O'Driscoll, the owners, gave me returns of 10 crushings amounting to which yielded 3,190 ounces of gold by battery amalgamation. In one crushing of 113 tons, which gave 138 ounces of gold, there was a further return of 32 ounces by cyanide treatment. The officially recorded figures show 732 tons crushed for the year ending April 30th, 1907. At this visit there was some fair stone at surface, in which gold was seen readily. This mine appears to me to have very good prospects of becoming an important one if opened up in a systematic way. The quartz from the winze contains some pyrites and blende.

*Bells and Round Hill* mines were not being worked at the time of our visit, and were not visited. They are said to return 15s. to 17s. per ton over the battery tables, but are not profitable for working under present circumstances.

*Battery 20-Mile Sandy.*—Most of the crushing for the district is done at the State battery, which consists of 10 stamps and 10 crushers; crushing charges are 14s. to 18s. per ton. Cartage is very heavy, one of the mines 10 miles distant, for example, pays 22s. a ton to send stone to the battery. In consequence of the high costs of working the ore must be of good grade to pay the charges. I was told of one mine close to the battery which was abandoned as unpayable although the returns from crushing were 15s. per ton over the tables, and the tailings yielded 10s. per ton to cyanide treatment. Some very rich ore has been treated at the mill occasionally, one parcel of three tons from the mine yielding 860.77 ounces of fine gold by plate amalgamation and 1.45 tons of sands for cyanide treatment assaying 1.45 oz. of gold per ton before treatment. This mine has returned 2 ounces of fine gold from six tons crushed during 1905.

The following table shows the returns from the 20-Mile Sandy



STATE BATTERY—20 MILE SANDY.  
Returns to 31st May, 1907.

Year.	Mine.	Tons crushed.	By Amalgamation.	By Cyanide.	Total.	Tons crushed.	Grand Total.
			ozs. dwts. grs.	ozs. dwts. grs.	ozs. dwts. grs.		ozs. dwts. grs.
1905	All Nations	39.5	49 0 0	9 1 21	58 1 21	39.5	58 1 21
1905	All Nations Extended	20.5	26 18 0	3 2 4	30 0 4	103 0 7	103 0 7
1906	Do.	49.5	118 4 0	14 16 3	133 0 3	70.0	70.0
1905	Ard Patrick	215.0	356 5 0	83 13 15	439 18 15	305.0	305.0
1906	Do.	51.0	353 12 0	48 7 2	401 19 2	1,027 2 17	1,027 2 17
1907	Do.	39.0	155 6 0	29 19 0	185 5 0	130.0	130.0
1905	Bow Bells	130.0	133 14 0	16 13 18	150 7 18	150 7 18	150 7 18
1905	Boulder	3.5	4 12 20	0 7 12	7 0 8	3.5	7 0 8
1906	Blue Spec	22.0	4 10 12	0 0 0	4 10 12	22.0	4 10 12
1905	Castlemaine	3.0	828 0 0	52 14 6	880 14 6	9.0	1,129 12 6
1906	Do.	3.0	223 2 0	18 18 0	242 0 0	9.0	9.0
1907	Do.	3.0	6 4 0	0 14 0	6 18 0	9.0	9.0
1905	Central	145.0	101 17 0	15 9 10	117 5 10	178.0	174 1 2
1906	Do.	33.0	44 4 0	12 11 16	56 15 16	10.0	42 9 12
1907	Central West	10.0	37 9 0	5 0 12	42 9 12	23 6 23	23 6 23
1905	Cowra & Brusher	35.0	20 7 0	2 19 23	23 6 23	34.5	34.5
1905	Chris. Watson	67.0	57 6 0	10 12 0	67 18 0	67.0	67.0
1906	Campbell's Hill	67.0	42 10 0	10 12 0	52 13 8	52 13 8	52 13 8
1907	Dretn	29.5	53 17 0	3 5 0	57 2 0	29.5	57 2 0
1908	Do.	51.5	31 0 0	14 2 7	45 2 7	51.5	45 2 7
1905	Endeavour	34.0	38 0 0	5 4 3	43 4 3	44.0	49 3 5
1905	Eureka	10.0	5 9 0	0 10 2	5 19 2	29.0	78 5 4
1907	Do.	12.5	49 4 0	5 2 0	54 6 0	3.0	34 12 0
1906	Emulation	16.5	21 13 0	2 6 4	23 19 4	31.0	24 7 5
1907	Do.	3.0	33 17 0	0 15 0	34 12 0	20.0	20 7 18
1908	Eldorado	31.0	21 6 0	3 3 1	24 7 18	31.0	31.0
1907	Emperor	31.0	17 0 0	3 3 1	20 7 18	31.0	31.0
1905	Emperor	31.0	17 0 0	3 3 1	20 7 18	31.0	31.0



[illegible]

The Table shows returns from 59 mines with a general average return of 20zs. 12d wts. 5grs. per ton, by amalgamation, followed by cyaniding of the sands.

*Ardpatrick G.M.L. 143.*—The main shaft of this mine is 135 feet, and there is a winze 75 feet below the bottom level. Water of consequence has been encountered in sinking. There is also a shaft 80 feet deep east of the main shaft; at the level in this the lode is seen to run east and west, and is about 6 feet wide between smooth walls which cut obliquely across the strata of the enclosing country schist. The quartz is from six to two feet six inches in thickness, and often has a considerable quantity of scheelite (tungstate of lime) mixed with it and closely associated with the gold. The scheelite might be worth some trouble to save by concentration if there were a railway to Marble Bar, but at present it is valueless. The *Ardpatrick* is rather a small one, but it has given some very good returns, official records being :—

		Tons crushed.	Fine ounces of Gold.
To end of 1906	...	314.00	gave 1098.48
" " May, 1907	...	39.00	" 148.06
Total	...	353.00	" 1,246.54
of Value £5,295.			

*Galtee Moore (79L) and (145L).*—This mine has a main shaft 212 feet deep, 177 feet being vertical, and 35 feet on the under the reef, and a second vertical shaft 100 feet deep. This reef runs about east and west, and seemed to me to be very similar to the Wonder Reef above mentioned, viz., a large jumbled "formation" between two main smoothed walls, which are nearly vertical. The country is slate and sandstone. The quartz occurs in rather irregular strings, lenses and bunches in the shattered zone between the walls, doubtless following more or less the openings between the masses of country with which the main fissure was originally filled or which were formed between them from time to time by faulting movements of the walls. The prospectors have worked closely to the quartz, and in consequence their workings are irregular in shape, and a great deal of handling of the ore is required underground. The mine has a good record of production and seems worth opening up systematically. On surface the mine has been worked eastward from the main shaft for about 300 feet, yielding some fair crushings. The recorded returns from the mine have been 1,252 tons crushed for 2,959.76 ounces of fine gold, April, 1907.

In the vicinity of the *Galtee Moore* and *Ardpatrick* mines are several other mines, which were not visited by our party, forming a belt of more or less parallel lodes which seem worthy of attention.

*Mosquito Creek Battery.*—At *Mosquito Creek* there is a light and old fashioned 10-head battery with three crude crushing vats. The battery well is 70 feet deep, sunk in a hard red granite.

is very suitable for ornamental purposes. The water is not very plentiful and gave out almost entirely in a recent season. A Government well is about 100 yards distant. It costs 35s. a cord at this battery.

*Battery* is close to the workings on the Parnell Reef. It consists of somewhat light stamps and a cyanide plant.

*Mill Mine* (95L).—The Parnell reef is a strong fissure lode running nearly east and west, traceable for about half a mile in length, having several shafts sunk upon it, the main one being the deepest, as is also that on the Federal Lease (109L) to the Parnell, on the same reef. The main ore shoot according to the pitch of the mine pitches easterly. At the time I visited it the men were at work close to the surface, taking out some very fine ore that had been left. The reef is a big strong one, over 100 feet deep, and looked very well in these shallow workings, but I did not go to the lower parts of the mine. The manager had about 100 tons of ore at grass which he expected would yield about an ounce of gold to the ton. This ore was raised by two men in ten weeks. The record shows a total of 2,220.35 tons crushed from the mine up to April 30th, 1907, for 2.158.98 ounces of fine gold.

*Old Reward.*—This old mine lies east of the Parnell, but the reef is somewhat north of the Parnell reef line showing either a fault or a parallel fracture, as is so common in these goldfields. The main shaft is about 60 feet deep, and there is another one about 60 feet further east. The men had taken up this ground again and were working on a reef 8 inches to two feet of stone said to be worth about an ounce of gold to the ton.









## OTHER CENTRES NOT VISITED.

Time prevented our party from visiting several other goldfields throughout the goldfield which are of much interest, but which have already been fully described in the Government reports in *Geological Survey Bulletins* Nos. 15, 20, and

*Mount Elsie and Boodalyerri* districts are described in *Bulletin* No. 15, which shows that the Elsie reef produced from 1899 to 1903 13,822 ounces (equal to 1,323.85 ounces fine) of gold from 3,000 tons of stone crushed, being a yield of 3.46 ounces per ton. Other claims have given 16.85 fine ounces from 20 tons. The Golden Granite mine at Boodalyerri has crushed 1,000 tons for 490.04 fine ounces of gold, or at the rate of 4.61 ounces per ton, besides giving 76.11 ounces from specimens. The Boodalyerri centre altogether has a record of produced 15,878.6 fine ounces from 120.25 tons of ore crushed and 76.11 ounces from specimens. According to the current local opinion expressed to us by various well-informed people at Marble Bar and allagaine, there are numerous low-grade reefs in the Boodalyerri district that might be worked if facilities were improved.

*Bamboo* centre is also described in *Geological Survey Bulletin* No. 15, and is notable for possessing in the *Bulletin* mine a long mining shaft in the Pilbara goldfield, viz., 400 feet, and is said to be the longest continuous shoot of ore yet worked. The ore which was shown to me at Marble Bar was very rich and charged with a good deal of sulphide of antimony. It is now working again.

The following table of production to end of 1903 is taken from *Geological Survey Bulletin* No. 15, page 61.

Table showing the yield of the Bamboo Reefs.

Name of Reef, etc.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
... ..	4'00	8'40	2'10
... ..	30'00	63'85	2'13
... ..	1,390'50	2,436'80	1'75
... ..	3,359'50	6,425'85	1'91
... ..	1,658'00	4,072'60	2'45
... ..	169'00	147'85	0'87
... ..	96'00	119'00	1'23
... ..	2,297'75	3,176'85	1'81
... ..	40'00	88'00	2'20
... ..	34'00	74'00	2'18
... ..	1,433'00	3,402'40	2'36
... ..	114'50	128'25	1'12
... ..	72'00	300'50	4'17
Total ... ..	10,698'25	20,444'35	1'91

*Since 1903 the official record gives to end of 1906: —*

	1904.				1905.				1906.				Total to end of 1906.			
	Dollied and Specimens.	Ore treated.	Gold therefrom.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Dollied and Specimens.	Ore treated.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Dollied and Specimens.	Ore treated.
	Fine ozs.	Tons.	Fine ozs.	Fine ozs.	Tons.	Fine oz.	Fine ozs.	Tons.	Fine ozs.	Tons.	Fine ozs.	Fine ozs.	Tons.	Fine ozs.	Fine ozs.	Tons.
(61) Bulletin (formerly Bamboo Consolidated G.M. Co.)	..	(cy.) 251.31	..	..	115.00	213.88	..	100.00	..	100.00	177.18	..	3,544.50	6,423.77	..	3,544.50
Voided leases ..	..	..	..	..	..	..	..	..	..	..	..	..	..	10,818.50	..	..
Sundry claims ..	116.75	8.00	102.22	2.95	..	..	2.95	..	..	..	..	119.70	144.00	454.40	..	..
	116.75	8.00	363.53	2.95	115.00	213.88	..	100.00	..	100.00	177.18	119.70	10,891.25	17,896.67	..	..

*Talga-Talga District* is described in *Geological Survey Bulletin* No. 15, from which the following table of returns has been taken:—

*Synoptical Table showing the Yield of the Talga Talga Reefs.*

Year.	Name of Lease, etc.	Ore crushed.	Gold therefrom.	Rate per ton.	Total ore crushed.	Total gold therefrom.	Average rate per ton.
		tons.	ozs.	ozs.	tons.	ozs.	ozs.
1895 1896	General, G.M.L. 485 .. ..	43.00	44.60	1.03			
	Do. .. ..	11.50	7.90	.68	54.50	52.50	.96
1897 1898	Jubilee G.M.L. 458 .. ..	91.00	137.00	1.50			
	Do. .. ..	33.00	45.90	1.39	124.00	182.90	1.47
Previous 1897	McPhee's Reward, Ltd., G.M.L. 55	367.00	957.00	2.60	367.00	957.00	2.60
1902 1897	Star of the North G.M.L. 124	18.50	19.00	1.03			
	Do. .. ..	97.00	115.74	1.19	115.50	134.74	1.16
1898	N.W. Goldfields, Ltd., G.M.L. 170	26.00	33.00	1.26	26.00	33.00	1.26
Previous 1897	Sundry claims .. ..	96.00	456.00	4.75			
1899	Do. .. ..	45.00	89.95	1.99			
1901	Do. .. ..	9.25	24.10	2.60			
1902	Do. .. ..	54.40	82.09	1.50	204.65	652.14	3.18
	Totals .. ..	..	..	..	891.65	2012.28	2.25

The official statistical returns to end of 1906 show only one later record, the Zephyr G.M.L. 616, having returned in 1904 83.83 fine ounces from dollied specimens, and 0.84 fine ounces from three tons of ore crushed.

The totals to end of 1906 are given as—

Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.
ozs. fine. 50.26	ozs. fine. 152.82	Tons. 779.15	fine ozs.. 1496.23

It would seem from this that the table in the *Geological Survey Bulletin* includes some yields not taken into account in the statistical record of returns reported to the Mines Department.

A sample of galena from a reef at Talga Talga given to me at Marble Bar by Mr. Riches, Inspector of Mines, has been assayed in the Geological Survey Laboratory with the following result:—

Lead (wet assay) ... 33.76 per cent.

ozs. dwts. grs.

Gold . ... 0 1 11 (0.073 oz.) per ton.

Silver ... 8 11 8 (8.567 oz.) per ton.

This does not show a high value in silver per unit of lead.

In *Bulletin* No. 15 also appear description of the *North Pole* and *Lalla Rookh* centres from which the following tables are quoted :—

*Synoptical Table showing the Yield of the Lalla Rookh Reefs to end of 1903.*

Name of Reef, etc.					Ore crushed.	Gold therefrom.	Rate per ton.
					tons.	ozs.	ozs.
Bergamini G.M.L. 606	...	...	...	...	186'00	101'00	54
Kitchener G.M.L. 569	...	...	...	...	38'50	37'10	96
Lalla Rookh R.C. 112	...	...	...	...	6,277'55	7,414'56	1'18
Sundry Claims	...	...	...	...	30'45	50'30	1'65
Total	...	...	...	...	6,532'50	7,602'96	1'16

During 1904, 1905, and 1906, the tailings on the *Lalla Rookh* mine were cyanided, yielding 2,078.79 fine ounces of gold. The total production of the *Lalla Rookh* centre to end of 1906 is given by the official statistics as 6,532.50 tons crushed for a total return of 7,717.51 ounces of fine gold.

*Synoptical Table showing the Yield of the North Pole Reefs to end of 1903.*

Name of Reef, etc.					Ore crushed.	Gold therefrom.	Rate per ton.
					tons.	ozs.	ozs.
North Pole Democrat G.M.L. 453	...	...	...	...	392'00	268'00	65
Try Again G.M.L. 575	...	...	...	...	24'00	56'40	2'35
Total	...	...	...	...	416'00	324'40	78

There were no returns in 1904, 1905, and 1906, and the total to end of 1906 is given in the Statistical record as 416.00 tons crushed for 277.02oz. of fine gold.

The fields which were not visited by our party seem from the Geological Survey descriptions to be quite similar to the other Pilbara gold districts in geological structure and mode of occurrence of the gold, being belts of greenstone schists of the Warrawoona series, usually close to a contact with granite, traversed by numerous dioritic and granitic dykes, containing large bars of jasperoid quartzites, and having the gold in quartz reefs of fissure vein type lying usually more or less parallel with the lamination of the schist.

#### ASBESTOS.

It has been known for some years that good specimens of chrysotile asbestos had been reported from the Pilbara Goldfield, but there seems to have been very little interest taken in the discovery, and no public information was available as to the precise locality in which the mineral existed until about two years ago, when the matter was taken up by Mr. Herbert Soanes. He found that the place where the asbestos had been got was in the

country to the west of Cooglegong, and obtained and sent to London about two tons of hand-picked mineral. "The Asbestos Co., Limited," was then formed with a capital of £100,000 to acquire and work the deposits. From the prospectus of the company it appears that the sample of fibre shipped was duly received by experts, and one ton (2,000lbs.) of different qualities was sold on its arrival for experimental treatment at £35." A letter from the well-known firm of Messrs. Bolling & Lowe on the value of the mineral, is also quoted in the prospectus:—

"2, Laurence Pountney Hill, London E.C.,  
2nd February, 1907.

*Directors of the Pilbara Asbestos Company, Limited.*

Gentlemen,—Judging from the sample of asbestos submitted to me by Mr A C. Gardiner, we have no hesitation in saying that the sample is as good as, if not better than, any No. 1 crude asbestos ever seen, and if the bulk of your production is equal to the sample we have little doubt that we could sell from 500 to 1,000 tons per annum through our various customers. We consider the price would range from £25 to £50 a ton delivered c.i.f., in London ports, and we could to-day sell a fair quantity of such asbestos as is indicated by your sample at the latter figure or a

We remain, yours faithfully,

(Sgd.) BOLLING & LOWE."

The analyses of the mineral received in Perth show it to be very soft and siliceous asbestos, of good colour and very silky lustre, and on rubbing into very fine fibres which exhibit great toughness and are roughly spun. Some of the natural bundles of fibre are brittle when the fibre has not been separated, but by a gentle crushing they separate out into good tough fibre. Some of the fibres are as much as six inches in length, which is very good. The mineral has every appearance of being of excellent

There was not time during our visit to the fields for the Hon. Mr. Justice and myself to visit this discovery. Mr. P. C. Riches, Engineer and Inspector of Mines, was instructed to make a report upon it, which he has done as follows:—

I left Marble Bar on 10th instant in company with Messrs. J. H. and Soanes, and arrived at the asbestos mine on the 12th instant. The mine is located in a very rough piece of country about 10 miles west of Cooglegong and about 21 degrees 30 minutes (approx.). We were unable to get within 2½ miles with the motor, and had to walk the remaining distance.

The asbestos lodes occur in a belt of serpentine country, running north-east and south-west, that lies more or less in a valley between the North and South by large jasper dykes. The



serpentine belt varies in width from 20 chains to about 5 chains, where it passes through a steep gorge at the south-west end of the traverse, after passing through this gorge it again widens out and extends with varying widths for another mile.

The asbestos lodes so far traced are two parallel lodes lying about a chain and a-half apart, and can be traced along the surface for about 30 chains, they appear to follow a diorite bar running parallel with it about ten feet away; the northern lode lies on the north side of the diorite while the southern lode is on the south side. It may possibly be found later that the whole of the country between these bars consists of diorite, but on the surface it appears to be serpentine, the bars themselves being only a few feet wide.

I found on arrival that very little prospecting work of any sort had been done, in fact the only work was a shaft 6ft. x 3ft. 6in. by 23ft. deep, and a pot hole about 4ft. deep, these were sunk by Mr. Soanes some 18 months ago.

Mr. Gardiner let me have a couple of men and I at once set them to work opening up the lode at various points, the shaft was also cleaned out and I then proceeded to sample the lode in the shaft, and also at the places that I had opened up.

The asb stos occurs in the lode where exposed in the shaft in veins running from mere threads to a bunch 6 inches wide. The large lode sample I have sent you shows a fair average of the deposits carrying the asbestos as it neither shows the very small or the large seams, it also explains for itself the occurrence of the mineral. In the bottom of the shaft, and also in the western end the lode is very much split up and is not nearly so rich as in the stope about 9ft. from the surface, however, the whole of the lode exposed in the shaft would probably average about 20 per cent. of asbestos.

On the surface I had shallow trenches cut across the lode at intervals, and found that at a depth of 18 inches the lode for a distance of 12 chains averaged about 2ft. 6in. in width, containing about 15 per cent. of fibre. I was unable to trace the south lode any further than the point at which sample 19 was obtained, but it is probably only hidden with over burden that has shot down the hillside, the blank holes that I had sunk being all in made ground.

On the north lode no work of any sort has been carried out, but it can be traced along the surface in a similar manner to the southern lode and would probably open up in a corresponding manner, as it appeared to me to be identical with the south lode, both as regards width and fibre at the two spots that I had opened up.

At various places on the surface and distant some chains from the two lodes already mentioned, pieces of loose decomposed serpentine can be picked up with asbestos veins from a mere thread to an inch wide running through them (notably the high hill where samples 23 and 24 were obtained). These specimens are scattered about



aces over a width of 30 feet. No lode can be traced on and an opinion as to the value of the deposit cannot be s some prospecting work is carried out.

regard to the statement contained in the prospectus of Asbestos Company, Limited, that there is 130,000 tons de asbestos available, Mr. Soanes assures me that he has y time expressed this opinion, and in support of his con- handed me his report on the property.

utterly impossible for me to give any estimate of the fibre available, if by available is meant the quantity in here is not, including what is in the dump, ten tons avail- l some development is done and it is ascertained whether and fibre live at a depth, and also the percentage of fibre e at these depths, it is utterly impossible for anyone to opinion as to the value of the mine or the amount of the ailable.

say that the proposition strikes me as a very favourable a my opinion is well worthy of some systematic develop-

aliarity of this discovery of chrysotile asbestos is that in t is found in more or less defined lodes of considerable ead of ramifying irregularly through masses of serpen- le most usual mode of occurrence elsewhere. The lodes less of the "segregation-vein" type, but there seems no doubt that they will be very persistent in depth. It is their very considerable linear extension that the cause produced them has operated on a fairly large scale along probably lines of shearing stress in the rock, and any eory of the formation of the mineral seems to necessarily persistency in depth as well as in length. As seen by Mr. ort above, the veins are of fair size, and contain a large fibre, the vein matter being rich rock from the asbestos int of view. In F. Cirkel's pamphlet on "Asbestos, its exploitation, and uses," issued by the Department of Canada—which country is the principal producer in the ne chrysotile variety of asbestos—an example is given of Canada, in fairly good ground, breaking 130 to 150 tons r day, which supplies 80 to 90 tons of rock for the mill. ns about  $7\frac{1}{2}$  tons a day of marketable asbestos, being per cent. of the rock milled and  $5\frac{1}{2}$  per cent. of the l. Expenses per ton of asbestos at this mine are given or £3 12s. 6d. Elsewhere in the pamphlet Mr. Cirkel the lowest percentage of milling rock in the Canadian bout 20 per cent., and the highest 70 per cent. of the mined, the average being 30 per cent. to 60 per cent., he milling rock returns 6 to 10 per cent. of marketed The annual export is about 30,000 to 35,000 tons of ineral of all grades, worth about \$1,000,000, or say

Most of the asbestos mining in Canada is open-cut quarrying, but there seems every reason to think that the greater richness in fibrous contents of the veins described above by Mr. Riches will much more than compensate for the greater cost of lode-mining. The discovery requires a good deal of opening up before there can be any certainty that it is one of much commercial value, but on present appearances it seems to be an extremely promising one, and is certainly worthy of thorough testing both as to the quantity of mineral obtainable and as to its quality for all manufacturing purposes for which it is used.

Some of the samples collected by Mr. Riches from close to the outcrop of the vein are much stained with oxide of iron, but this is only a superficial feature due to weathering, which will soon disappear in depth.

A sample of this asbestos received some years ago by the Government Mineralogist and Assayer from a former Registrar at Tambourah was analysed by him, and found to be practically identical in composition with Canadian and Italian asbestos, as shown by the following analyses :—

	Italian.	Canadian.	Tambourah.
	per cent.	per cent.	per cent.
Silica ... ..	40.30	39.05	42.98
Magnesia ... ..	43.37	40.07	39.92
Iron protoxide ... ..	...	...	{ .24
Iron peroxide ... ..	.87	2.41	{ 1.68
Alumina ... ..	2.27	3.67	.44
Water ... ..	13.72	14.48	14.82
Total ...	100.53	99.68	100.08

According to Canadian authorities the largest bulk of the asbestos mined there is quite short, being between one quarter and one half inch in length. The mines usually first hand-dress their product, sending the longer fibre to cobbing sheds, where it is separated by hand into two grades, No. 1 measuring over  $\frac{3}{4}$  inch in length of fibre, and No. 2 exceeding  $\frac{1}{8}$  inch. The waste from this work and the rock containing short fibre are crushed, and the fibres separated from the crushed matrix rock by shaking screens, suction fans, and other devices. The mills produce three grades of product known as "long spinning fibre," "spinning fibre," and "paper stock." The prices per ton (of 2,000lbs.) in 1905 were about as follows :—

Hand-dressed, No. 1 Crude,	\$175 to \$200 or, say,	£36—£42
No. 2 "	110 " 125 "	23— 31
Milled, Fibre No. 1	75 " 80 "	16— 17
" No. 2	50 " "	10
Paper Stock	20 " 25 "	4— 5

The Canadian production of all grades in 1905 was 50,670 short tons, valued at \$1,486,359, equal to an average value of \$29.33 or £6 2s. 3d. per ton.

## SUMMARY OF MINERAL PRODUCTION.

The following table gives a short general summary of the Mineral Production of the Pilbara and West Pilbara Goldfields as reported to the Mines Department to end of April, 1907:—

	Pilbara.			West Pilbara.			Total.	
	fine ozs.	Value. £	fine ozs.	Value. £	fine ozs.	Value. £		
Gold ...	128,015·12	543,770	16,219·86	68,897	144,234·98	612,667		
Silver ...	574·01	72	...	...	574·01	72		
Copper Ore ...	...	...	tons. 13,447·00	140,236	tons. 13,447·00	140,236		
Tin Ore ...	3,202·09	262,285	...	...	3,202·09	262,285		
Tantalite ...	85·60	11,569	...	...	85·60	11,569		
Ironstone ...	...	...	tons. 100·00	300	100·00	300		
Diamonds ...	(weight un- known)	24	...	...	(weight un- known)	24		
Total	...	£817,720	...	£209,433	...	£1,027,153		

Gold taken at £42/17 per oz. fine; Silver at 2s. 6d. per oz.

The figures are incomplete, a good deal of gold having been produced that has not been properly recorded, not to speak of some small parcels of tin, copper, and antimony ores known to have been raised which have not been included. The gold bullion entered for export and received at the Perth branch of the Royal Mint from the Pilbara and West Pilbara Goldfields to end of April, 1907, amounts to 230,406.47 fine ounces, or no less than 86,171.49 ounces of value £366,031 more than the total of 144,234.98 fine ounces reported to the Mines Department. The silver returns are also very deficient, that alloyed with the gold not appearing in the above table except in a few cases where it has been separately returned by the mine owners. The total mineral production may therefore safely be valued at not less than £1,400,000.

#### CONDITION OF THE FIELDS.

The foregoing detailed description of the various mining districts shows them all in a most serious condition of very feeble activity or total stagnation except the recently resuscitated copper mines near the coast, and the tinfields. A very short examination of the gold-mining centres is sufficient to impress upon any observant visitor the inadequacy of the working trials that have been for the most part given to the reefs. The workings are nearly all very shallow, and very little driving and cross-cutting have been done as a rule, attention having been mostly confined to stopping out rich bunches of ore. Very few of the mines have had any machinery upon them for pumping water or raising and treating the ore, nearly all of the output of gold being the result of windlass work. The values in the reefs have doubtless been erratic, but when the bunches of rich ore followed from surface have given out there have been far too many cases of the mines being abandoned without any apparent effort having been made to search for similar bunches by systematic development. The reefs are often of very fair size, and mostly of a character to give considerable confidence in their permanency in depth. I could see no sufficient grounds at all for the pessimism very often expressed as to their carrying gold in depth, and for the belief that the gold in them is merely superficial, but on the contrary while there has, probably enough, been a good deal of superficial enrichment of the shallower oxidised portions of the reefs, it seemed to me that the ore from the deeper workings, often carrying gold associated with pyrites, copper pyrites, and stibnite, was of a very permanent type, belonging to the original substance of the reefs, and little if at all likely to have been affected by secondary enrichment. Though patchy distribution of the values in bunches and shoots will very likely at all times continue to characterise the reefs, there is little good reason for fearing that their systematic development in depth will not result in the discovery of good ore at frequent intervals.

The recorded returns of crushings to end of April, 1907, show that 79,718.62 tons of ore crushed in the two goldfields yielded

127,974.32 fine ounces of gold, or at the rate of 1.65 fine ounces per ton, not including the gold from specimens dollied, which is properly to be credited to the reefs also. This is an average value for the whole of these fields of £7 per ton of quartz crushed, which is an excellent return, especially when it is considered that it is the average over a large number of small contributing mines. As has been seen, however, district after district has languished or died, and in every case the causes have been the same, namely high costs of working under present conditions, and want of regularity in the values carried by the reefs. The latter of these causes can best be met by sufficiently extensive development to average the irregularities, but there has been too little of such work done in these fields to enable any reckoning to be formed yet of the extent to which the necessary development work would affect the general mining costs. This can only be found in each case by actual trial. The high costs of working are due to scarcity of timber and fuel, and great want of facilities in obtaining machinery, mining supplies, and all the ordinary necessities of life.

The high cost of timber and firewood is due to the scarcity of good forests in this goldfield, it being often necessary to cart the firewood 6 to 10 miles, and mining timber 10 to 50 miles or more. For most structural purposes Oregon timber carted from the coast is the cheapest available. Round mining timber for ordinary sets and props often costs up to 1s. per lineal foot, and firewood 35s. to 45s. per cord. The only possible cure for this drawback is a means of cheaply importing timber and fuel from the coast.

The want of facilities in obtaining goods of all sorts re-acts on costs of every kind. The cost of living is high and therefore wages must be high. Miners' wages are from £4 a week in the more accessible districts to £4 10s. and even £5 at Nullagine, and other sorts of labour in proportion. Beef and mutton are obtainable at fairly reasonable rates, though not so cheaply as might be expected in a pastoral district, but nearly all other foodstuffs have to be imported. Flour is retailed in Marble Bar at 13s. per bag of 50lbs., tea at 2s. to 2s. 6d. per lb., sugar at 5d. per lb., or 25s. per bag., tinned meats 1s. per tin or 11s. per doz. tins, rice 21s. per bag of 56lbs., tinned fruit 14s. per doz. or 1s. 3d. per tin, tinned milk 10s. per doz. At Nullagine foodstuffs are much dearer, and an unusual state of affairs was disclosed in that people were finding it actually cheaper to have small parcels of onions, eggs, potatoes, butter, and similar goods sent to them by parcel post from Fremantle than to purchase them from the local stores after being sent at freight rates in storekeepers' quantities by steamer and wagon or camels. Freights on goods from Port Hedland to Marble Bar by wagon or camel team run from £6 to £14 per ton, £9 being about an average figure for ordinary domestic supplies. To Nullagine is £6 to £8 more, making say on the average £17 a ton from Port Hedland or £19 a ton from Fremantle. Nearly all building materials are



imported, and I heard of as high as £14 a ton being the price for freight of timber and iron required at Marble Bar and Port Hedland. On heavy mining machinery, such as boilers, are very much above those ruling for ordinary freight.

Not only do the high costs of transport add greatly to the cost of all supplies, but there is also a really much more formidable obstacle to mining progress in the terrible loss of time involved in getting them from the coast. It takes three days for a light cart to go from Port Hedland to Marble Bar, a distance of 100 miles, the road being mostly sandy, and heavy wagons take eight days to do the same journey. From Marble Bar to Nullagine is 100 miles, taking the teams four to six days more. It is quite impossible therefore for mining stores for the inland centres to be sent to be sent for from Fremantle, the journey from which to Port Hedland takes a week, and steamers leave at weekly to fortnightly intervals, it is rarely possible to get them delivered on the coast less than four weeks from the time of telegraphing for them. Quite frequently it takes six or seven weeks. When orders are sent by letter and there is necessary delay in getting them to Perth or Fremantle, as is often the case with orders to factories and foundries, it may easily be over two months before the goods reach the mines. Any breakdown of important machinery which cannot be repaired locally is therefore liable to cause a total stoppage of the work of the mine for a very serious period. Delays of this sort and loss of time through struggling with primitive shift methods of getting on without the proper appliances are the cause of great increases in mining costs, far more than the actual cost of the machinery or goods which are waited for.

While railway communication between the fields and the coast would not entirely remove these disabilities by any means, it would go a very long way towards doing so, enabling goods to be sent into the interior at greatly reduced rates and minimising the loss of time in procuring supplies which has been so serious a drawback. It also of course greatly facilitates travelling of persons, enabling people to go from the interior to the coast and *vice versa* in a matter of days instead of three or four, and at much less cost.

#### MINING LOW-GRADE GOLD ORES.

With such high costs as have prevailed in the past, the mining of the fields it has been quite impossible to work any but the very best of the ore at a profit. The high average value above quoted of £7 a ton is only another way of expressing the same thing, no one having found it worth while to take the poorer stuff to the mills. It would be very much opposed to mining experience, however, to infer from what has been said that the ore in the mines could be divided into two classes,



averaging £7 a ton and poor ore not worth touching at all, it being much more usual that there should be a gradation of value from the richest to the poorest, with, commonly, much more of the lower grades of value than of the higher. From my examination of the mines I see no reason for thinking that the reefs of the Pilbara fields will behave otherwise than usual in this respect, and would regard the 79,719 tons of £7 ore which have been crushed from them as very strong *prima facie* evidence that there are some hundreds of thousands of tons of say 30s. to 40s. ore left in the neighbourhood of the richer shoots. With improvements of mining facilities by railway communication much of this could be profitably handled.

#### MINING FOR BASE METALS, ETC.

It has been shown in the foregoing that besides gold the Pilbara district also contains good tinfields, and that good copper, silver, lead, and antimony ores have been found in several localities. The costs of realising copper ores have been well shown previously in the case of Mr. Bonner's parcel from North Shaw, and it is clear that ores from still more distant localities can only be exported at even higher cost. Copper ores are reported to have been found away in the eastern portion of the Pilbara Goldfield, to the east of the rabbit-proof fence, and it is obviously quite impossible for anything to be done with such mines while costs of working and of getting the ore to market are so prohibitive as now. Unless some of these mines turn out to be able to maintain smelting works of their own, the only hope of getting any return from the ore is by exporting it, and only the richest ore will now pay costs of doing this. Very few mines however are able to exist for long merely on the export of their richest ore, and the only hope of enabling the more inland base metal mines to be worked for any length of time lies in greatly improving the existing facilities of transport so as to give cheap carriage of ore to overseas markets and cheap working costs that will allow a much lower grade of ore to be shipped, until such time as the mines are able to support their own concentrating mills or smelting works.

The tin mines are in a rather better position than those of lead and copper in this regard, as the milling and concentration of tin ores is a comparatively simple and inexpensive process which produces a rich dressed product able to support high transport charges. The milling and dressing mills nevertheless must have rapid means of communication with foundries and central supplies of stores if they are to be maintained in the good working order necessary for cheap working costs.

Minerals of comparatively low initial value such as crude asbestos, mica, and ornamental stone, all of which exist in the Pilbara fields, are of course especially affected by costs of transport, there being no possibility of exporting them to a market unless the cost of carriage is kept down to a very low figure.

## RAILWAY COMMUNICATION AND ROUTES.

If, therefore, the Pilbara fields are to be developed as their record of production and their promise for the future warrant, it is absolutely necessary that they should be opened up by a railway from the coast. This is generally admitted by all who know the fields, but there is great diversity of opinion as to the best route to be followed. Three starting points on the coast have been seriously considered, Port Hedland, Balla Balla, and Point Sampson, and more than one route suggested from each.

One line has actually been surveyed, from Port Hedland southeasterly across the coastal plain for about 77 miles to Gorge Creek, where it reaches the edge of the mountainous country, thence along the north edge of the latter for about 18 miles to a pass to the east of the Doolena Gap, thence south 20 miles to Marble Bar, a total distance of 115 miles. From Marble Bar the survey has been carried on to Nullagine, passing on the north side of the Warrawoona range, crossing it between Warrawoona and Yandicoogina, and thence running south to Nullagine, a total distance of 180 miles from Port Hedland. This line passes through country which has not yet been proved to be metalliferous for the first 77 miles, but at this point would become of great benefit to the Lalla Rookh and North Pole fields, which lie about 25 miles to the south, and from Gorge Creek onwards would be in the most convenient position practicable for a line serving the unproved mountainous country to the north of a line connecting Lalla Rookh and Marble Bar, which, from its geological structure, is likely to be auriferous. At about 95 miles it can be reached from the Bamboo field in about 28 miles, a little farther south it passes close to Talga Talga, and at Marble Bar it meets the converging roads which centre there from Moolyella, Yandicoogina, Warrawoona, and Cooglegong. If then continued on to Nullagine it would serve Warrawoona, Yandicoogina, Nullagine, and the Middle Creek and Mosquito Creek Districts, following much the same route as the road from Marble Bar to Nullagine. Marble Bar is the existing distributing centre for these fields, and appears to be so for good geographical reasons. If the railway from the coast were only carried as far as Marble Bar it would still be very beneficial to the fields just mentioned, to all of which there are fairly good existing roads. The extension to Nullagine would be an immense help to Warrawoona, Nullagine, and Mosquito Creek fields, and would be almost a necessity for extensive working of the Nullagine conglomerates, but it is not of the same immediately vital necessity as the section to Marble Bar, and might be deferred for a time.

The second proposed route from Port Hedland is one running a more southerly course for about 50 miles to Poonthuna Pool and then turning almost due east to rejoin the first route at Gorge Creek. The detour increases the length of the line by about 17

miles. Its object is to bring the route nearer Wodgina, which could be reached in about 27 miles from it, and it would be of service to the tin-bearing district of Mt. York also. The patches of greenstone and schist country seen on the geological map at Cooke's Hill and to the south of Mt. Dove are likely places for mineral discoveries, though not as yet known to be valuable, and would be served very well. This route would run within 10 to 20 miles of the north-western edge of the mountainous but probably auriferous country lying north-east and south-west from Lalla Rookh, and would, therefore, be of direct service to a much larger extent of likely mineral country than the first one. The assistance it would afford to the known centres of Wodgina and Lalla Rookh, together with its good chances of opening mineral country at Cooke's Hill, Mt. Dove, and between Wodgina and Gorge Creek, have to be considered seriously as against the greater length of 17 miles which it involves in first construction, and for all time on freights to points further inland than Gorge Creek. As things stand at present there is not enough known mineral development to justify departure from the first direct route, but I am nevertheless strongly inclined to believe that the detour will prove to be the best solution of the difficult problem of giving the best service possible in this district of scattered mining centres.

Two other routes have been mentioned which are variations of the second one just described, namely, one southward from Poonthuma Pool to Pincunah Hill, and thence by North Shaw and Just-in-Time to Marble Bar, the other more directly from Poonthuma through the hills to Marble Bar. These routes are only feasible on the map, the country to be traversed being so rough and broken as to render them out of the question. Doubtless they are practicable if sufficient money were spent, but they would be terribly expensive, and need not be seriously taken into consideration in existing circumstances. The lines of railway, it must be recognised, must go round the big island of rough country shown in green on the geological map, and not through it.

A third route from Port Hedland would continue through Poonthuma Pool, pass west of Pincunah Hill, and run down the west side of the greenstone island to a point between Woodstock and Tambourah, where it would have to cross a narrow range of hilly country to reach the plains of the Upper Shaw. This crossing might be expensive work, but probably a practicable line could be got without very much trouble. The line would then best run as straight as possible towards Nullagine, which would be reached in about 170 miles, or 10 miles less than the northern route *via* Marble Bar. A long branch line would be required to reach Marble Bar and Moolyella *via* Warrawoona from this route. If instead of going from the crossing of the range near Tambourah directly towards Nullagine, the line were taken through Cooglegong and Just-in-Time to

Marble Bar, it would have a good deal of rough country to traverse and would be much longer than the northern route. No. 3 route would serve Wodgina, Tambourah, and Western Shaw fields well, would open likely country along the west side of the greenstone island, would suit the asbestos discoveries, and the Cooglegong and Shaw tin-fields, besides serving Nullagine as well as the northern route. The value of the country traversed is, however, much less, both according to records of production and present appearances of future success than of that which would be opened by the northern route, and on the evidence at present available the latter (route Nos. 1 and 2) is greatly preferable. From Wodgina onwards to Nullagine, however, this No. 3 route would be identical with proposed lines coming inland from Roebourne or Balla Balla.

The fourth route to be considered is from Balla Balla *via* Whim Creek, Mallina, and Station Peak to Wodgina, thence going on to Nullagine and Marble Bar on route No. 3, just described. It would have the advantage of passing through proved mineral country all the way. It would be about 180 miles to Nullagine, and 193 miles to Marble Bar *via* Corunna Downs and Warrawoona, which is probably the most practicable route. In many ways this is the most desirable railway line of all those proposed, but it would require a lot of expenditure in furnishing the terminus at Balla Balla with wharfage and other landing facilities to fit it for general traffic.

Route No. 5 from Point Sampson and Roebourne might run along the coastal plain to Whim Creek to join No. 4 there, but would more probably go by Croydon to join No. 4 near Station Peak, opening up a line of rather promising country that would not be served by the coastal line, but leaving the important Whim Creek field to be worked as at present through Balla Balla. These alternative routes would require, I think, to be actually surveyed and carefully estimated for before a choice could be properly made of one or the other. It is very possible that an expenditure at Balla Balla on improvement of shipping and landing facilities, of no greater amount than would be required to bring the line round by Whim Creek over and above the cost of its construction *via* Croydon, might make that port quite equal to the needs of the Whim Creek District. Sufficient data are not yet available for full consideration of this question.

The distance from Point Sampson to Nullagine *via* Whim Creek, Station Peak, Wodgina, and Tambourah, is about 225 miles, and to Marble Bar 218 miles; *via* Croydon it would be about five miles less. In the present state of the West Pilbara and Pilbara fields, along the routes both from Roebourne and Balla Balla there does not seem to me to be the same inducement to build a railway as there is for the Port Hedland routes, Nos. 1 and 2 above. The best

parts of the West Pilbara field so far worked are quite near the coast, and do not require railway communication with the same urgency as the inland fields. Improvement of the means of landing and shipping cargo at Point Sampson by connecting the jetty there with the Roebourne-Cossack tramway would go a long way towards removing the disabilities under which the mines of the Roebourne District suffer, and the railway would not improve their condition much until we come to such as are in the more outlying fields like Croydon and Station Peak. A line terminating at Balla Balla would suit the interior fields even better than one ending at Point Sampson, if equal shipping facilities were provided.

*Terminal Port.*—The choice of the best route for opening up these goldfields depends very greatly on the relative suitability of the ports proposed as coastal starting points. It seems to me that in many ways this is the most important question of all, the securing of a good port being of much greater consequence than getting the shortest length of railway construction. A railway is a very permanent work, and once its starting point is fixed there will be very little chance of ever reconsidering the question, as vested interests will soon be created which will render a change practically impossible. It is therefore incumbent on us to look ahead as well as at immediate requirements, and try if possible to secure a port which can be progressively improved as time goes on so as to meet expansion of traffic.

Port Hedland is at present by far the best of the three ports that are available, inasmuch as the coastal steamers come up to a wharf in a well-protected, land-locked basin where they can take on board and discharge cargo with ease and despatch. Railway trucks can be run right alongside the vessels and there is plenty of room for extension of the wharves. By dredging, as the needs of the port require it, it will be possible to greatly enlarge the deep water basin, and with the aid of walls regulating the currents to straighten the tortuous channel by which the harbour is entered. So far as the land-locked portion of the harbour is concerned there seems every possibility of improving it from year to year so as to become in time a very fine harbour. But there seems very little chance of its ever being anything but a tidal port, as the bar outside the entrance is a wide series of hard reefs, the channels through which are only safely navigable when the tide is well up. There does not seem much possibility of effecting any considerable improvement in this respect, the reefs being too extensive and far out to sea to be dealt with. There is, however, over 20 feet of rise of the tide, and at high water the entrance is not formidable. Many well-known ports are tidal ones, however, and the inability to enter Port Hedland at all times of the tide, though a drawback to it, need not be regarded as a very serious detriment.

The shores of the Port Hedland steamer basin are very low-lying, being only a few feet above high water mark, and it is somewhat doubtful what protection they would afford to vessels if the port were struck by one of the fierce cyclonic storms that every now and then occur on this part of the coast. If a vessel could not get out to sea in time, through the tide not suiting, it would have to endure the storm as best it might at its anchors and moorings in the basin, with practically no protection from the wind, though a good deal sheltered from the worst force of the seas. There seems to be considerable doubt on the part of nautical men as to the security of shipping caught in the harbour in such a storm, and in this regard the inability to get promptly out to sea at any time does seem to be a serious drawback to the port.

The port at Balla Balla at present consists of a small tidal creek from which the water runs almost entirely out at low tide, but which is navigable for small craft when the tide is high. There is a small jetty, from which ore is lightered out to steamers lying outside, and which serves to receive incoming goods. The coastal steamers lie outside the mouth of the creek in a somewhat narrow channel of deep water lying between the north end of Depuch Island and the mainland. This anchorage is well sheltered on the south side by Depuch Island, which is a high rugged rocky hill of greenstone. There is deep water right in along the channel to the anchorage, but this is still some distance out from the shore. Nautical opinion seems to favour this as one of the best ports on the N.W. Coast, there being good shelter in most winds and clear ingress from and egress to the open sea at all times of the tide. There seems, however, to be a deficiency of information as to what is possible to be done in the way of making it a port fit to be the terminus of a railway, and I understand further surveys are now being undertaken to ascertain what can be done. The best landing is said to be on Depuch Island, which would necessitate the connection of this with the mainland by a long causeway and bridge in order that railway trucks should run to the steamers' sides. I have not been able to ascertain if projects of running out long jetties from the mainland side are at all feasible. It is fairly certain that very large expenditure would be required to enable the steamers to lie alongside any railway wharf. From what I have been able to learn about this port, however, there seems a better chance of eventually making it a really good one than either Port Hedland or Point Sampson, and the results of the surveys now being carried out will therefore be very important, for, should they confirm this opinion, it would be well worth consideration whether it would not be better to face the necessary expenditure here than to go on spending money at Port Hedland with only a tidal port to look forward to in the end. The possibility of working the port for a time with a tidal



railway jetty on the mainland, and a steam lighter service between it and the ocean-going steamers has also to be considered, as it might be feasible to begin in this way at not too great a cost and go on with a larger scheme later on. At present no conclusion can be come to for want of sufficient data.

At Point Sampson a fine jetty has been made to deep water, and the coastal steamers can come alongside it at any time of the tide. It would, however, require much strengthening and widening to make it fit for a terminal railway wharf. This jetty is very open to the sea, but I have been informed that there are usually but few days in each year on which vessels would be prevented by heavy weather from mooring alongside the jetty. There is good open water for coming in and getting out, and in threatening weather steamers could put safely out to sea at any time. How far the jetty itself could resist the full force of a cyclonic storm has not yet been demonstrated by actual experience, and there is much difference of opinion on the matter. It is certainly much more exposed to the full force of the seas than would be the jetties at either Balla Balla or Port Hedland, and would have to be enormously strong to be able to successfully resist the terrible weather which sometimes strikes the North-West coast. Whether the present timber jetty is able to do so or not may perhaps be questionable, but there is no doubt that if required the resources of modern engineering in steel and ferro-concrete structures are capable of dealing with even the most violent seas.

At present the Point Sampson jetty is mainly used for shipment of cattle and sheep, there being no practicable approach to it on the land side for loaded vehicles. It could, however, be easily connected with the Roebourne-Cossack tramway by a branch line from this, and there is no engineering difficulty in the way of starting a railway from it. For immediate requirements of the Roebourne district the connection with the Cossack tramway is urgently required, the large expenditure already incurred in building the jetty being practically useless so far as goods are concerned until the connection is made. Goods from the steamers are sometimes now put on Point Sampson jetty to be lightered thence to Cossack, and ore brought out of Cossack Creek by the lighters is sometimes lifted from the Point Sampson jetty by the steamers, but except for convenience of deposit when direct lightering is not possible it is of little use except for live stock. The Cossack harbour is a tidal one, only suitable for small craft.

So far as an immediately workable terminal port for the railway is concerned it will be seen therefore that all the advantage lies with Port Hedland, and unless Balla Balla turns out to be much more easily made workable than at present anticipated, it is obvious

that large expenditure will be required both there and at Point Sampson to provide the facilities required at a railway terminus.

*Railway Route Recommended.*—While the routes from Roebourne and Balla Balla to Nullagine via Wodgina present many advantages in the matter of opening up likely country, they are the least suitable for the service of the parts of the Pilbara goldfield which have been the most productive hitherto, and which have therefore the first claim to be provided with railway communication. They are also the longest routes, and so would be the most costly lines to construct and work. Lastly they start from ports which would require much larger immediate expenditure upon them to fit them to be the starting point of the railway than does Port Hedland, while there seem better possibilities of eventually making the latter a protected and safe harbour than at either Balla Balla or Point Sampson, though these both have the advantage of a better get-away to sea. The No. 1 route, that already surveyed, from Port Hedland to Marble Bar, therefore seems the one that must be recommended as the best according to present knowledge, but though as yet there is no strong justification, except the Wodgina district, for the detour to the south constituting route No. 2, the extra chances which it gives of opening mineral country go far to counterbalance the increased length. As a matter of personal belief I favour route No. 2 rather than No. 1, but must admit that my reasons for the preference are more speculative than demonstrable. If there were any reasonable hope of serving the Wodgina district in the near future by a line from Balla Balla or Roebourne opening the West Pilbara fields, it would be best to keep to Route No. 1, but as the next most important line in this district to that from Port Hedland to Marble Bar is its extension from Marble Bar to Nullagine or Mosquito Creek, it is hardly likely that a third railway can come within practical politics for a long time, and the detour of No. 2 route seems the best compromise.

*Traffic for Railway.*—It is very little use at present trying to make any estimate of the traffic the railway will have on the basis of present population and amount of goods carried by teams. There are some 1,200 people in the country served by the line, and the monthly import of stores of all sorts into Marble Bar is stated to be about 120 tons. These figures of themselves obviously do not justify a railway, but when we look at field after field lying dormant for want of facilities for development, it is equally obvious that the country is capable of supporting a large population, able to make a railway pay handsomely.

I have not dwelt in this report at all upon the pastoral resources of the Pilbara fields, but they are very great, and the number of sheep and cattle raised and the acreage of land enclosed in stock paddocks is very rapidly increasing. The general prosperity of

this region is very marked, and there seems no doubt the great value to the State of the pastoral industry. The effect of the construction of a railway to Marblehead station country can be taken up still further back, at present the workable range from the coast. From what I have learned during the trip I have every reason to believe that there will be considerable inland expansion of pastoral holdings if a railway is decided upon.

I have, etc.,

A. MONTGOMERY, M.A., F.G.S.,

State Mining Engineer.

## GOLD PRODUCTION OF PILBARA GOLDFIELD.

As reported to the Mines Department to 30th April, 1907.

Mining Centre.	Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.
	Fine ozs.	Fine ozs.	Tons, (2,240lbs.)	Fine ozs.	Fine ozs.	Fine ozs.	Tons, (2,240lbs.)	Fine ozs.

## MARBLE BAR DISTRICT.

To end of—												
1906	Bamboo Creek	..	..	119.70	10,891.25	..	17,696.67	..	..	119.70	10,891.25	17,696.67
1907	Do.	..	..	..	..	..	..	..	..	..	..	..
To end of—												
1906	Bockalyerrie	..	..	148.85	120.25	..	587.86	..	..	148.85	120.25	587.86
1907	Do.	..	..	..	..	..	..	..	..	..	..	..
To end of—												
1906	Breen's Find	..	..	..	14.00	..	66.82	..	..	..	14.00	66.82
1907	Do.	..	..	..	..	..	..	..	..	..	..	..
To end of—												
1906	Elsie	..	..	..	135.00	..	316.31	..	..	..	135.00	316.31
1907	Do.	..	..	..	..	..	..	..	..	..	..	..
To end of—												
1906	Lalla Rookh	..	..	..	6,532.50	..	7,717.51	..	..	..	6,532.50	7,717.51
1907	Do.	..	..	..	..	..	..	..	..	..	..	..

To end of— 1906 1907	Shark's Is.	.. ..	145.08 ..	19.37 ..	6.00 ..	33.00 ..	7.53	567.03	351.45	674.72
To end of— 1906 1907	Shaw River Do.	.. ..	.. ..	.. ..	101.00 ..	49.63 ..	..	..	101.00	49.63
To end of— 1906 1907	Talga Talga Do.	.. ..	50.26 ..	152.82 ..	779.15 ..	1,496.23 ..	50.26	152.82	779.15	1,496.23
To end of— 1906 1907	Tambourah Do.	.. ..	.. ..	64.65 ..	2,077.75 ..	2,536.88 ..	..	64.65	2,077.75	2,536.88
To end of— 1906 1907	Warrawoona Do.	.. ..	44.30 ..	338.15 ..	7,456.09 ..	16,211.63 ..	44.30	338.15	7,456.09	16,211.63
To end of— 1906 1907	Western Shaw Do.	.. ..	.. ..	4.77 ..	1,221.00 ..	930.73 ..	..	4.77	1,221.00	930.73
To end of— 1906 1907	Wyman's Well Do.	.. ..	.. ..	47.68 ..	292.40 ..	872.07 ..	..	47.68	292.40	872.07
To end of— 1906 1907	Yandicoogina Do.	.. ..	.. ..	373.36 ..	2,768.25 ..	5,718.33 ..	..	373.36	2,768.25	5,718.33
To end of— 1906 1907	District generally Do.	.. ..	5,918.72 95.34	217.05 ..	237.95 ..	1,120.77 25.19	6,014.06	217.05	237.95	1,145.96
	Total	..	..	..	..	..	6,270.17	2,224.37	42,602.13	71,848.56

GOLD PRODUCTION OF PILBARA GOLDFIELD—continued.  
As reported to the Mines Department to 30th April, 1907.

	Mining Centre.	Alluvial.		Dollied and Specimens.		Ore treated.		Gold therefrom.		Alluvial.		Dollied and Specimens.		Ore treated.		Gold therefrom.	
		Fine ozs.		Fine ozs.		Tons, (2,240lbs.)		Fine ozs.		Fine ozs.		Fine ozs.		Tons, (2,240lbs.)		Fine ozs.	
NULLAGINE DISTRICT.																	
To end of— 1906 1907	Elsie .. Do. ..	.. ..	.. ..	.. ..	.. ..	428.25 ..	1,340.70 ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	428.25 ..	1,340.70 ..	.. ..	.. ..
To end of— 1906 1907	Mosquito Creek Do. ..	.. ..	.. ..	166.47 ..	6,354.49 199.00	10,289.54 377.62	.. ..	.. ..	.. ..	.. ..	.. ..	166.47 ..	6,553.49 ..	.. ..	10,667.16 ..	.. ..	.. ..
To end of— 1906 1907	Nullagine Do. ..	104.70 ..	.. ..	105.19 ..	14,096.40 95.50	21,754.99 190.42	.. ..	104.70 ..	.. ..	105.19 ..	14,191.90 ..	.. ..	.. ..	.. ..	21,945.41 ..	.. ..	.. ..
To end of— 1906 1907	20-Mile Sandy Do. ..	.. ..	.. ..	14.36 ..	2,807.60 69.00	6,723.11 92.43	.. ..	.. ..	.. ..	14.36 ..	2,876.60 ..	.. ..	.. ..	.. ..	6,815.54 ..	.. ..	.. ..
To end of— 1906 1907	District generally Do. ..	3,902.02 70.10	.. ..	22.50 ..	38.50 ..	2,517.87 ..	.. ..	3,972.12 ..	.. ..	22.50 ..	38.50 ..	.. ..	.. ..	.. ..	2,517.87 ..	.. ..	.. ..
	Total ..	..	..	..	..	..	..	4,076.82	3,972.12	308.52	24,088.74	..	..	..	43,286.68	..	..
	GRAND TOTAL PILBARA (GOLDFIELD)	..	..	..	..	..	..	10,346.99	..	2,532.89	66,690.87	..	..	..	115,135.24	..	..



## APPENDIX.

### CHRYSOTILE ASBESTOS FROM NEAR COOGLEGONG.

Referring to the description by Mr. P. C. Riches, of the Pilbara Asbestos Company's mine, quoted in the foregoing report, the following are his notes on samples forwarded with his report and the report of the Government Mineralogist and Assayer upon them :—

#### MR. RICHES' REPORT.

No. of Bag.	Remarks.
1	Taken from pot-hole at North-East end of lode.
2/10	Taken from shaft.
7	Apparent hanging wall.
8	Apparent foot wall.
11	Average sample of dump.
12	Lode 12 inches wide, going 15 per cent. fibre, depth from surface 1 foot
13	Lode 18 inches wide, going 15 per cent. on surface.
14	Lode 2 feet wide, going 20 per cent., depth from surface 1 foot.
15	Lode 2 feet wide, going 20 per cent fibre, depth from surface 1 foot, much decomposed.
16	Lode 18 inches wide, going 20 per cent., fibre depth 2 feet from surface, much decomposed.
17	Lode 3 feet wide, going 15 per cent., fibre depth from surface 18 inches
18	Width of lode 3 feet, going 15 per cent. fibre, depth from surface 2 feet.
19	Lode 2 feet wide, going 20 per cent. fibre, depth from surface 2 feet.
20	Lode 8 inches wide, going 20 per cent. fibre, depth from surface 6 inches
21	Lode 3 feet wide, going 20 per cent. fibre, depth from surface 18 inches much decomposed.
22	Sample of dlorite bar.
23/24	Surface samples.
25/26	Specimens of long fibre. Also two large specimens of lode showing occurrence of Asbestos veins.

#### GOVERNMENT MINERALOGIST AND ASSAYER'S REPORT.

I have examined the 28 samples of asbestos and associated rocks from Tambourah District with the following results :—

- 3653 No. 1.—Weight 7 ozs. Rock and fibre, both much broken and weathered. No commercial value.
- 3654, No. 2.—Weight 1lb. 13ozs. Asbestos vein  $2\frac{1}{2}$  to  $2\frac{3}{4}$  inch wide, interrupted by central vein. Total first quality fibre about 95 per cent. Length of fibre,  $\frac{1}{2}$ in. to  $1\frac{1}{2}$ in., average about  $1\frac{1}{4}$ in.
- 3655, No. 3.—Weight 1lb. 15ozs. Serpentine with veins of asbestos. Fibre about 50 per cent. of whole, mostly first quality, but a little ironstained. Veins  $\frac{1}{2}$ in. to  $2\frac{1}{2}$ in., with partings. Fibre,  $\frac{1}{2}$ in. to  $1\frac{1}{2}$ in., average  $\frac{3}{4}$ in.
- 3656, No. 4.—Weight 1lb. 8ozs. Asbestos vein with adhering rock. Yield of fibre about 80 per cent. Vein, 2in. to 3in. Fibre,  $\frac{1}{2}$ in., to  $1\frac{1}{2}$ in.; average,  $1\frac{1}{4}$ in.
- 3657, No. 5.—Weight 12 ozs. Broken fibre from vein of about 3in. Partly discoloured and weathered. Length  $\frac{1}{2}$ in. to 3in.; average, about  $1\frac{1}{2}$ in.

- 3658, No. 6.—Weight 1lb. 13ozs. Green serpentine with veins of asbestos. Fibre about 60 per cent. Veins  $\frac{1}{2}$ in. and less up to  $1\frac{1}{2}$ in.; fibre up to 1in., and of varying quality. Average length about  $\frac{1}{2}$ in.
- 3659, No. 7.—Weight, 1lb. 13ozs. Purplish serpentine with one or two very narrow veins of asbestos. Under the microscope this rock is seen to be composed of massive structureless serpentine with very numerous inclusions of black and brown iron ore.
- 3660, No. 8.—Rock. Serpentine still preserving some of the structure of the original rock in the shape of partly altered olivine crystals and grains of ilmenite with leucoxene.
- 3661, No. 9.—Weight, 1lb. 9ozs. Green serpentine with numerous small veins of asbestos. Yield, about 50 per cent. of fibre, up to  $\frac{1}{2}$ in. in length.
- 3662, No. 10.—Weight, 1lb. Asbestos vein with adherent serpentine. Width of vein,  $2\frac{1}{2}$ in. to  $2\frac{1}{2}$ in. Fibre about 85 per cent. Length,  $\frac{1}{2}$ in. or less up to  $2\frac{1}{2}$ in.; average,  $1\frac{1}{2}$ in.
- 3663, No. 11.—Weight, 2lbs. Green and purple serpentine, showing no structure under the microscope, with veins of asbestos. Sample much broken. Yield, about 25 per cent. Veins from threads up to 1in. Fibre, up to  $\frac{1}{2}$ in.; average, about  $\frac{1}{2}$ in.
- 3664, No. 12.—Weight, 1lb. 8ozs. Much weathered and fractured asbestos with a little rock.  $3\frac{1}{2}$ in. vein represented. Too much weathered to be of value.
- 3665, No. 13.—Weight, 9ozs. Weathered serpentine with numerous veins of asbestos up to  $\frac{1}{2}$ in. in width. Considerably weathered and probably of little value.
- 3666, No. 14.—Weight, 10ozs. Green serpentine with veins of fibrous and sub-fibrous material. Suitable only for preparation of asbestic.
- 3667, No. 15.—Weight, 11ozs. Much weathered and ironstained asbestos with a little rock.— $1\frac{1}{2}$ in. vein represented. Valueless.
- 3668, No. 16.—Weight, 1lb. 10ozs. Serpentine with many weathered and stained veins of asbestos up to  $1\frac{1}{2}$ in., in width. Fibre,  $\frac{1}{2}$ in. or less up to  $\frac{1}{2}$ in.
- 3669, No. 17.—Weight, 1lb. 6ozs. Serpentine with veins of asbestos up to  $\frac{1}{2}$ in. Yield, about 30 per cent. Fibre partly discoloured. Length, up to  $\frac{1}{2}$ in.; average  $\frac{1}{2}$ in. to  $\frac{1}{2}$ in. Rock shows a reticulated structure under microscope, and is evidently an altered olivine rock.
- 3670, No. 18.—Weight, 1lb. 7ozs. Serpentine with veins of asbestos. Yield, about 40 per cent. Veins, threads up to  $1\frac{1}{2}$ in. Fibre, mostly under  $\frac{1}{2}$ in., and of inferior quality.
- 3671, No. 19.—Weight, 13ozs. Serpentine, with veins of discoloured and inferior asbestos, with fibre up to 2in.
- 3672, No. 20.—Weight, 12ozs. Asbestos, with a little adherent rock. Fibre much weathered and discoloured. Veins, up to 2in.; fibre, up to  $1\frac{1}{2}$ in.; average, about  $\frac{1}{2}$ in.
- 3673, No. 21.—Weight, 13ozs. Much weathered and ironstained asbestos from vein about 2in. Average length of fibre, 1in.
- 3674, No. 22.—This rock appears to be the least altered of those in the series. It consists largely of serpentine, and appears to approach in character the serpentinised augite-picrites of some parts of Cornwall.
- 3675, No. 23.—Weight, 2lbs. 2ozs. Serpentine and asbestos veins, one 2in. in width. Yield of fibre, 30 per cent., mostly 2in. in length. The rock in this sample appears to have a felted structure, and may, therefore, be used for the preparation of asbestic.
- 3676, No. 24.—Weight, 1lb. 8ozs. Similar to last, but more weathered. Greatest length of fibre 1in.
- 3677, No. 25.—Weight, 2lbs. 8ozs. First grade asbestos with a little adherent rock. Vein  $5\frac{1}{2}$ in. to  $6\frac{1}{2}$ in. wide with partings. Fibre up to 5in.
- 3678, No. 26.—Weight, 1lb. 14ozs. First grade asbestos with a little adherent rock. Vein about 6in. to 7in., with partings. Fibre up to 4in.; average 2in.

3679, No. 27.—Weight, 24lbs. Large block of green serpentine, with numerous small veins of asbestos. Proportion of fibre by measurement, 25 per cent. Veins up to 2in.; fibre up to  $\frac{1}{2}$ in.; average about  $\frac{1}{4}$ in.

3680, No. 28.—Weight, 7lbs. 9ozs. Smaller block similar to last. Proportion of fibre by measurement, 21 per cent. Length up to  $\frac{1}{2}$ in.; average  $\frac{1}{4}$ in.

The asbestos in all these samples is of the chrysotile variety. It will not be out of place to re-quote here the analysis of a typical sample from this locality made some little time ago.

Silica	..	..	..	..	..	..	..	42.98
Magnesia	..	..	..	..	..	..	..	39.92
Manganese protoxide	..	..	..	..	..	..	..	Trace
Iron protoxide	..	..	..	..	..	..	..	.24
Iron peroxide	..	..	..	..	..	..	..	1.68
Alumina	..	..	..	..	..	..	..	.44
Water above 100°	..	..	..	..	..	..	..	12.88
Water at 100°	..	..	..	..	..	..	..	1.94
								<hr/> 100.08
Sp. gr.	..	..	..	..	..	..	..	<hr/> 2.37

Samples 27 and 28 are of especial interest as showing that the mode of occurrence is identical with that in other asbestos mines throughout the world, the fibrous serpentine (asbestos) occurring in numerous irregular veins in an intrusive mass of serpentine rock. The original rock, of which this is the altered form, may have been an augite-picrite.

The veins in the samples submitted have usually an anastomosing habit, and vary from  $\frac{1}{4}$ in. or less, up to 7in. in width, but the length of the fibres is almost always less than the width of the veins for two reasons:—

- (a.) They appear to have grown from both sides of the fissure at once, and to have met along a plane coated with non-fibrous material.
- (b.) After their growth was complete, minute movements in the walls have given rise to planes along which the fibres are kinked and liable to be broken on handling.

In spite of this, the samples submitted contain a high proportion of asbestos of excellent quality over half an inch in length, which would be in Canada classed as No. 1 and No. 2 grades, whilst there appears to be a certain proportion of similar fibre of exceptional length which should command exceptional prices.

(Sgd.)

EDWARD S. SIMPSON, B.E., F.C.S.

Mineralogist and Assayer.



1906.

WESTERN AUSTRALIA.

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# GEOLOGICAL SURVEY.

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BULLETIN No. 24.

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**Averton, Burtville, and Erlistoun  
Auriferous Belt,**

**MARGARET GOLDFIELD,**

BY

**CHAS. G. GIBSON, B.E.,**

**Assistant Geologist.**

---

*under the authority of the Hon. H. Gregory, M.L.A.,  
Minister for Mines.*

---

**3 GEOLOGICAL AND MINING MAPS, 7 FIGURES,  
AND 26 PLATES.**

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**PERTH:**

**AUTHORITY: FRED. WM. SIMPSON, GOVERNMENT PRINTER.**

1906.









## PREFATORY NOTE.

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port makes another of the special series dealing with  
ferent mineral fields of the State.

ort and accompanying maps represent the results of  
Gibson's investigations in a portion of the Mount Margaret  
and include descriptions of the mining centres of Laverton,  
the Erlistoun district, together with an account of the  
Berry Ranges, Mounts Shenton, Venn, Warren, and  
and the Ulrich Range.

work upon which Mr. Gibson's observations are based,  
began on the 15th of May and completed on the 26th  
of June, 1905.

In addition to this officer's own work, Mr. Gibson's report in-  
cludes an *aperçu* of the labours of the other official observers  
of the district, and is accompanied by a series of geological and mining  
maps which make the descriptive portions of the report intelligible.

The rocks of the district comprise a complex of crystalline rocks,  
of which that which forms the auriferous series in other portions  
of the State and therefore need no further reference in this place.

A. GIBB MAITLAND,  
Government Geologist.

Survey Office,  
Perth, 27th July, 1906.



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# Laverton, Burtville, and Erlistoun Auriferous Belt, MT. MARGARET GOLDFIELD.

## Boundaries of the Field.

The Mount Margaret Goldfield, which was previously included in the North Coolgardie Field, was declared, by proclamation, gazetted on the 12th March, 1897, to take effect from the 1st April of that year; its boundaries were amended by a further proclamation, gazetted on 28th March, 1902, taking effect on the 2nd April, 1902, so as to embrace an area of 42,252 square miles.

The boundaries, as defined by the authorities, are as follows :—

"Bounded by lines starting from a point about fifteen miles East, and about thirteen miles North from the summit of Mount Ida, and extending  
"North about thirty-five and a-half miles; thence East about sixty-seven and a quarter miles, passing through a tree marked A.N. 33,  
"at Doyle's Well; thence North about fourteen miles; thence East about seven miles; thence North to the 26th parallel of South latitude; thence East to the 125th meridian, East longitude; thence South to a spot due East of a tree marked B. 82, at Brickey's Soak; thence West through the said tree to the starting point. Excluding all townsites and fee simple lands within the boundaries."

*Mining Centres examined and mapped.*—The centres examined and reported on were Laverton (including Lancefield and Ida H.), Burtville, Erlistoun, Duketon, Mulga Queen, and the country at the Cosmo Newberry Ranges, and in the vicinity of Mounts Shenton, Venn, and Warren, as well as the reported new find situated in the Ulrich Ranges, 60 miles north-east of Duketon. Of Laverton, Lancefield, Ida H. (Heaphy's Find), and Burtville, geological sketch maps have been prepared on a scale of 20 chains to one inch; while of Erlistoun, Duketon, and Mulga Queen, black and white maps have been made showing the positions of the principal lines of reef.

*Early History of the Mount Margaret Goldfield.*—The earliest mention of the Mount Margaret district is found in the journal of Sir John Forrest, when he was in command of the West Australian Expedition in search of the remains of Dr. Leichardt and party in 1869, and the history of the district may, therefore, be said to start with the following extracts from his diary of the expedition :—

"June 20th, 1869 . . . . . Saw a high hill bearing N. 81° 30' E., mag. and about twenty-five miles distant, which I named Mount Leonora, and another bearing N. 67° E., mag. about twenty-five miles distant which I named Mount George. Intend proceeding to Mount Leonora to-morrow . . . . ."

"June 21st. Steering towards Mount Leonora over some tolerably grassy country, we reached it at sundown and camped . . . . . in South latitude 28° 53' by meridian altitudes of Lyræ (Vega) and Aquilæ (Altair) and in longitude about 121° 21' East

- " June 23rd . . . . . Passing Mount Leonora we steered N. 81° 15° E. mag. to a table hill, which . . . . . I called it Mount Malcolm . . . . . Saw a remarkable peak bearing N. 65° E. mag. distant about 20 miles . . . . . which I named Mount Flora . . . . . and from which I obtained a round of bearings. Saw a high range bearing about N. 106° 15° E. mag. apparently about sixteen miles distant, towards which we travelled till after dark . . . . .
- " June 24th. Saddled at dawn and proceeded to the range, which bore N. 93° 30° E. mag. about five miles distant, on reaching which I ascended the highest point and named it Mount Margaret . . . . . From the summit of Mount Margaret the view was very extensive. There was a large dry salt lake to the southward as far as the eye could reach, while to the East and North-East there were low trap ranges lightly grassed. A high table hill bore N. 73° E. mag. . . . .
- " July 1st . . . . . Reached the table hill, which I ascended, and took a round of angles. I have since named this hill Mount Weld, being the farthest hill seen eastward by us."

From that date but little further knowledge was gained of the country, or, indeed, little attention was paid to it for more than twenty years; and it was not until 1894 that the Mount Margaret, or Lake Carey, country began to be regarded as a rising and prosperous district.

At the end of 1895, the population of the whole of the district amounted only to 730; there were 3,400 acres held under mineral lease, and two ten-stamp batteries were erected at Mount Margaret.

During 1896 numerous new finds were reported, principally at Mount Margaret, Mount Malcolm, Mount Leonora, and Murrin Murrin, whilst an important discovery of copper was made six miles to the east of Princess Alex. (Murrin Murrin); townships also sprang up at these places.

It was not until 1st April, 1897, that the Mount Margaret was constituted an independent goldfield, formed by separating portions of the North Coolgardie and East Murchison Goldfields. It had at this time an area of 19,166 square miles, and was divided into the districts of Mount Margaret, comprising an area of 17,150 square miles, and Mount Malcolm, with an area of 2,516 square miles.

Apparently at the time, the centre of Mount Malcolm gave promise of being the most important, and the Warden's office for the transaction of the departmental business of the new field was opened there on the 10th May, 1897. On the 24th December, in the same year, the area of the Mount Margaret district was increased to 39,638 square miles, by the inclusion of a portion of the East Murchison Goldfield.

In this year, the Westralia Mount Morgans Gold Mines was registered as a local company, and on 3rd March following the Sons of Gwalia, Ltd., which gave great impetus to the mining centres of Leonora and Morgans, these two mines being the chief producers of the field. The Under Secretary for Mines in his Annual Report for 1898, refers to the developments of the field during that period as being little short of phenomenal.

population at the end of 1898 was 1,725.

the boundaries of the districts were further amended, Mount Margaret district comprised an area of 39,510 acres, and the whole field an area of 42,154 square miles. In 1900, a public battery started operations at Leonora, and copper deposits were found and furnaces erected at Murrin Murrin, where similar ores were previously located. The yield of gold for the year amounted to 9.6 per cent. of the total production of the State. Developments were very satisfactory in the following year (1901), especially in the vicinity of Mount Margaret, and to the east and south-east of it. In 1901, 4,539 tons of copper ore were treated at Anaconda. The gold yield rose from 5 per cent. to 9.6 per cent. of the State's production, a proportion which increased to 10.3 per cent. in 1902. When the copper output from Murrin, valued at £40,738, was added, it was rather more than half the State's total. The Warden reported at the end of 1901, that progress was marked in the direction of legitimate development of prospecting shows, and that at a depth than by the opening up of new country; which also apply to the following year when, however, the copper showed a falling off, the output being only valued at £30,000. During this year (1901) a State battery was started

In 1902 the gold production maintained its satisfactory level. Two new townships were declared at Burtville and Euro, and a battery was erected at Laverton. A slight alteration was made in the administration of the field by the creation of the district of Mount Morgans, the centres being Malcolm, Morgans, and Euro, and the area of the field 42,252 square miles; the headquarters were removed to Morgans, which thus became the administrative centre. The relative importance of the districts during this year is shown by the following comparative

District.	Population.	Production.
Leonora (including Leonora) .. ..	2,741	Fine ozs. 78,171.96
Mount Margaret .. ..	1,114	51,092.42
Mount Morgans .. ..	2,170	57,554.60

In this year the railway from the coast was opened to Leonora.

In 1903, the North Erlistoun district began to attract attention, and a railway was opened from Malcolm to Laverton. The gold production rose to 9.31 per cent. of the State's total.

State batteries were erected at Burtville and Duketon, and the output rose to 9.59 per cent. of the State's total.

The following table shows the gold returns in fine ounces from the areas covered by the three districts of Mount Morgans, Mount Malcolm, and Mount Margaret up to the end of 1905 :—

	Prior to 1897.	1897.	1898.	1899.	1900.	1901.	1902.	1903.
Mount Morgans	294.06	3,376.34	8,641.76	14,652.97	31,819.52	41,607.09	51,092.42	59,517.40
Mount Malcolm	3,887.01	15,051.71	29,638.28	46,399.13	77,235.19	84,278.40	78,171.96	83,529.04
Mount Margaret	267.32	695.88	3,841.20	9,202.44	17,800.40	39,357.52	57,554.60	39,717.48
Total	4,448.39	19,123.93	42,121.24	70,254.54	126,855.11	165,243.01	186,818.98	182,763.92

	1904.	1905.	Total.
Mount Morgans	45,230.33	25,877.33	Fine ozs. 282,109.22
Mount Malcolm	94,300.27	105,897.45	618,388.44
Mount Margaret	43,992.65	56,937.93	269,366.92
Total	183,523.25	188,712.21	1,169,864.58

## Previous Observations on the Geology of the Mt. Margaret Goldfield.

In a report on the Interior Gold Region of Western Australia, \* published in 1894, Mr. S. Göczel, describing the country passed over on an expedition from the "Ninety Mile" to Lake Carey, mentions the Lake Raeside depression which he crossed some miles to the south of Mount Leonora, and which forms the drainage area of the southern portion of the field. He noted the position of the large outcrops of granitic rocks which rise as a range of bare hills to a height of 200 feet above the surrounding country, and form, with a width of about five miles, the divide of the water-shed of Lakes Raeside and Carey. Mr. Göczel further stated that a long stretch of country situated at the junction of this gneissic granite on the west and the greenstone on the east had already been proved auriferous, and he mentions the "Red Castle" line of reef, and the "Goose's Puzzle," and stated that though rich finds had not been made up to that time, a number of reefs offered chances for profitable mining enterprise. Farther east, on the range of which Mount Margaret forms the highest point, he referred to alluvial gold deposits at Red Flag, Hawk's Nest, and other surface workings—the Hawk's Nest being the richest.

Since this date no detailed official reports on the district appear to have been made until 1904, when Mr. C. F. V. Jackson, then Assistant Geologist, issued a detailed report on and map of Leonora,† following this up next year with a similar report and map of Mount Morgans.‡

In the same year, 1904, the State Mining Engineer (Mr. Montgomery) published a short report on the Erlistoun and Duketon districts,§ in which he says:—

"The country between these two places (Laverton and Duketon) appears to be favourable throughout for the occurrence of gold, a large number of auriferous reefs having been found at intervals throughout it. It is mostly the usual greenstone of our goldfields, often schistose, while the surface is plentifully strewn with concretionary ironstone, and often with white quartz. Bars of black jasperoid quartz and outcrops of white quartz occur frequently . . . . ."

" . . . . . The Erlistoun and Duketon districts are yet in quite the first stage of development, and require a great deal more prospecting and opening before their importance can be justly estimated. Even a flying visit is, however, sufficient to show that the reefs are numerous, and have prospects of gold sufficient to justify high hopes of their future. The impression gained by me was that there was a very valuable district to be exploited."

According to Mr. Jackson's observations, the fundamental rocks of Leonora consist of a complex of crystalline schists, which form the continuation of that group which is so largely developed in other portions of the Eastern Goldfields; these schists comprise both basic

\* Annual Report of the Department of Mines for 1894, Perth: By Authority: 1895.

† Geology and Auriferous Deposits of Leonora, Mt. Margaret Goldfield. Perth: By Authority: 1904.

‡ Geological Features and Auriferous Deposits of Mt. Morgans, Mt. Margaret Goldfield. Perth: By Authority: 1905.

§ Annual Report of the Department of Mines for 1904. Perth: By Authority: 1905.

and acidic rocks. Some of the basic rocks (the greenstones) have been converted into schists which are largely developed along the outer margin of the main belt, whilst the centre portion is occupied by the more or less massive rocks; these schistose and massive rocks are merely portions of one and the same mass which has suffered more or less dynamical metamorphism. All the important ore deposits are confined to the greenstones and their derivatives. The greenstones have been invaded by granitic rocks, which are both massive and foliated, and evidence seems to prove that these are of two distinct ages, (a) an older, traversed by zones of secondary shearing, possibly associated with auriferous quartz reefs, and (b) a much newer and comparatively unmodified granite, which is represented by the felsite dykes, which are found intersecting the greenstones in the vicinity of the Leonora Gold Blocks. Speaking of the Mount Morgans centre, Mr. Jackson remarks that the staple formation consists of a series of basic and acidic rocks of the geological age, of which the district affords no direct evidence, though in all probability it forms part of the same series as that so largely developed in other portions of the Eastern Goldfields, and invariably assumed to be Archæan. The basic rocks, the greenstones, are essentially hornblendic, and have to a considerable extent been converted into schists, these being most prominent along the junction of the greenstones with the granitic rocks. The acidic rocks consists chiefly of quartz and felspar porphyries, and appear to be intrusive into the greenstones; like the latter they have been subjected to considerable local mechanical deformation, and have been converted into what may, for convenience, be best described as granitic schists.

The ore deposits of the Mount Morgans district Mr. Jackson separates into two main divisions,—

- (a.) Lodes which are genetically similar to the banded and hematite-bearing quartz reefs, which form such conspicuous features in the Murchison and Mount Margaret Goldfields; and
- (b.) Gold-bearing quartz reefs of the ordinary type.

The banded quartz lodes form a series of bold outcrops on the summit of the main Mount Morgans ridge, and have been traced across country for about four miles, occurring along the main junction line between the greenstones and the porphyry. They vary much in size, and are very irregular; their chief characteristic is that of a solid body or pipe of lens section, the main axis of which dips to the south at an average angle of about 45 degrees. The ore chutes also have a marked trend to the southward.

The second division, the normal quartz reefs, are found almost entirely within the greenstones to the eastward of the main dividing ridge. It will thus be seen that there is a great similarity in the geological features and mode of occurrence of its ore deposits between this centre and that of Laverton.



## Laverton.

(Including Ida H. and Lancefield.)

(With three Geological Sketch Maps, Plates I., II., and III.)

**Topography.**—The townsite of Laverton, which forms the present terminus of the Eastern Railway, is situated on the eastern side, and near the northern edge of a low, irregular ridge of hills trending in a roughly north and south direction for some four miles or so. Easterly from here, the country consists of level plains extending for about six miles, when another low ridge makes its appearance, also trending north and south through Ida H. and Cock of the North; easterly from here the country consists of alternating low greenstone ridges and loamy plain for many miles. Westward of the main ridge of hills, the country also consists of alternating low ridges on flats for some half-a-dozen miles, when extensive sand plains come in, extending as far as Mount Morgans.

Northerly from the townsite are extensive flats extending for many miles, and broken only by the ridge of hills, of which Mount Crawford forms the highest point, and which extends for only a couple of miles: beyond this again, the plains continue indefinitely.

### General Geology.

Broadly speaking, the formations of Laverton can be divided into two classes, the greenstones and the granites. Of these, the greenstones occupy by far the larger area, and are of by much the greater importance, as it is within them that the extensive H.B. quartz lodes and other auriferous deposits occur. These greenstones are of the types usually found in the West Australian gold-fields, and comprise both massive and foliated varieties as well as occasional small areas of schist, these latter being usually found in close proximity to the granitic rocks. These granitic rocks occupy a comparatively small area, chiefly in the neighbourhood of Mount Crawford, and to the West of the Augusta G.M. They are apparently intrusive into the greenstones. The greater part of the area under examination is covered by a varying thickness of recent detrital deposits, which render accurate mapping almost impossible. There are also a few small areas of laterite throughout the district occurring as the cappings of greenstone hills; they are, however, of small extent and inferior quality.

**The Recent Deposits.**—These cover by far the greater portion of the area under examination to depths varying from a few inches to probably 50 or 60 feet, and consist of the accumulated detritus from the older greenstones and granites; where overlying and derived from the former they are of a fine red clayey nature, but when derived from the granite, they are much looser, more sandy and lighter in colour, this difference in appearance being often the only guide as to the nature of the underlying rocks. The boundaries

between these superficial deposits and the outcropping rocks, as shown on the map, are for the most part only approximate, as the point at which the former cease is very indefinite, and is generally purely arbitrary.

The deposits of ironstone gravel (laterite) which form so conspicuous a feature on most of the Eastern Goldfields are not developed to any large extent in this district; a few small isolated patches occur as the cappings of low weathered greenstone hills, principally towards the southern portion of the area examined, but they are, as a rule, of inferior grade. As to the origin of these laterites, it is generally agreed that they have resulted from the gradual concentration and deposition of iron oxide resulting from the weathering of the older basic rocks *in situ*. Almost the only high-grade deposit in the district occurs as the capping of a low greenstone hill about half-a-mile south-east of the old Mount Barnicoat G.M. (*Photograph 1.*)

*The Granitic Rocks.*—These vary through felsites, felspar porphyries, and granites, and are found as intrusive dykes and masses in the greenstones, being most largely developed in the northern portion of the district near Mount Crawford, and also to the westward of the Augusta G.M., where they are evidently portions of the extensive mass lying to the east of Mount Morgans. A specimen [6535], from the eastern side of the main body east of Mount Crawford, near G.M.L. 126, is a dark massive variety very closely resembling a coarse-grained quartz diorite in appearance; under the microscope, however, a section shows it to be a fairly typical granite, consisting, in addition to quartz and felspar, of both biotite and hornblende, both considerably weathered and altered, the latter into a green chloritic material, and the former partially into hornblende. Going westerly this has the appearance of passing gradually through all stages from a dark hornblende granite, or quartz diorite, to a light-coloured quartz porphyry. Sections of specimens [6534, 6533], of these show them to be practically the same rock, the only difference being that the hornblende is less in quantity in the more western variety. In the vicinity of the Augusta G.M., the prevailing type is a fairly coarse-grained rock, ranging from an aplite to a quartz porphyry; the smaller dykes, however, are usually of fine grained, compact felsites and rocks not unlike quartzites.

*The Greenstones.*—The group of rocks to which the general term greenstone has been applied is of by far the greatest economic importance of any in the district, as it is almost solely within them that the auriferous ore bodies are found. These rocks occupy by far the greater portion of the area examined, and consist of both massive and foliated varieties, though it has not been possible to separate the two on the map. It is also possible that there may be more than one variety of basic or ultra-basic rock, but no more

GEOLOGICAL SURVEY.

PHOTO. 1.

*Bulletin 24.*



Photo., C. G. Gibson.

**Laterite Hill, Laverton.**

Govt. Photo. Litho.



than structural distinctions can be observed—a coarse-grained, a fine-grained and a schistose variety being most prominent; the areas occupied by each are not sufficiently well-defined for separate mapping, nor is there any satisfactory evidence with regard to the geological relation of the several varieties, and it has been assumed, as on the other goldfields, and probably correctly, that they are merely local variations of one and the same basic or ultra-basic rock; sections of them show them to be essentially hornblende rocks, ranging through almost typical diorites to a fine-grained rock, consisting almost entirely of hornblende; in the coarser-grained specimens [6527] the hornblende is a very pale to colourless variety (tremolite), and in the fine-grained it is a light to dark green variety (actinolite).

These greenstones are for the most part considerably decomposed and weathered, such weathering being greater on the eastern side of the district, along the Ida H. and Cock of the North line of country, where there has been considerable north and south foliation and a large and well-defined development of the remarkable banded and hematite-bearing quartz lodes, together with the accompanying leaching of the surrounding rocks. This line of country apparently marks a main line of jointing extending over a width of half-a-mile or so, and extending roughly north and south through the Ida H., Cock of the North, and Scotland Yet leases for seven or eight miles.

About two miles west of Ida H. is an outcrop of hard, massive hornblende rocks apparently closely allied with those forming the auriferous series and differing from them only in their hard and unweathered appearance; they form a ridge of low, bare hills occupying a comparatively small area and rising to a height of 30 to 50 feet. An analysis of this rock [6540] made in the Departmental Laboratory is as follows:—

Silica	..	..	..	..	..	59.35
Carbonic anhydride	..	..	..	..	..	.06
Titanium dioxide	..	..	..	..	..	.78
Combined water	..	..	..	..	..	.83
Soda	..	..	..	..	..	3.38
Potash	..	..	..	..	..	.90
Magnesia	..	..	..	..	..	4.58
Lime	..	..	..	..	..	6.43
Manganese protoxide	..	..	..	..	..	.33
Iron protoxide	..	..	..	..	..	1.76
Iron peroxide	..	..	..	..	..	5.41
Alumina	..	..	..	..	..	15.83
Pyrates { iron	..	..	..	..	..	.03
{ sulphur	..	..	..	..	..	.04
Hygroscopic water	..	..	..	..	..	.07
						<hr/> 99.78
Specific gravity	..	..	..	..	..	<hr/> 2.86

The greenstones are traversed by occasional dykes. These can seldom be followed on the surface, but met with in the mine workings; one [6556] cut in the of the Ida H. G.M. is some 20 feet in thickness, and runs mainly east and west, being almost vertical in its dip; moderately coarse-grained, dark massive rock, a section seen under the microscope, shows it to be an augite dolerite, with phenocrysts of augite in a holocrystalline ground mass of lath-shaped feldspars and granules of augite and magnetite.

These dykes are newer than the quartz reefs and bearing quartz lodes which they cut through, but without placing them to any extent.

*Ore Deposits.* — These are conveniently divisible into three classes :—

- (a.) Lodes which are genetically similar to the hematite-bearing quartz lodes, which are so conspicuous a feature of the Murchison and Margaret Goldfields.

- (b.) Quartz reefs of the normal type.

In this respect they exactly resemble those of Mount Isa, which have already been described by Mr. Jackson in Bulletin No. 16 of the Geological Survey.

The former are most highly developed immediately to the east of the town along the main ridge, where they occur in the form of bold outcrops extending for several miles. They are genetically similar to the hematite-bearing quartz lodes ("quartzites") of the Murchison Goldfield, where they extend as roughly parallel, often continuous for many miles in length: they are usually one to three chains in width, and outcrop in the form of serrated ridges. These bands are merely quartz reefs of a peculiar type, and vary in composition from almost pure quartz through varieties of banded jaspers, often of great beauty, to hematite, and finally to tectonically pure banded hematite. \* They have already been described in detail in earlier Bulletins (Nos. 8 and 14)—

"as old fault or joint lines along which the greenstones have been foliated . . . and by a gradual lode forming process come to their present state."

At Laverton they are found in all gradations, from pure quartz and hematite, through pure banded quartz to banded hematite, to tectonically unaltered schist. They are all more or less auriferous, but only in very few cases are they sufficiently so to pay for working. Examples of this type of deposit are being worked at the Murchison, Lancefield, and Great Bedford (Cock of the North) gold mines. These particular deposits will be more fully described when dealing with the individual mines. They usually have a moderate

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\* Bulletin No. 16, p. 25.



lenticular form on the surface, these lenses varying in length from a few chains to half-a-mile or more, and having an average width of from 20 to 100 feet. The deposits along the Ida H. and Cock of the North line have this form to a very marked extent, and on this line they show a greater variation in their appearance and composition than elsewhere, varying from banded ferruginous quartz to a soft ironstained weathered schist, usually silicified and hard near the surface, and often with a capping of hard siliceous limonite.

A good example of non-ferruginous type is seen in the belt forming the ridge of which Mount Crawford is the highest point; there the main bar which forms the apex of this hill has a width of from 2 to 3 chains, and consists of almost pure compact blue and white quartz. This belt extends fairly continuously for about a mile and a half, but becomes a good deal more broken and irregular at its northern end; it also becomes much more ferruginous here.

Quartz reefs of the normal type are often associated with these hematite-bearing lodes, being as a rule small, and usually running along either foot or hanging wall; they are evidently of later formation than the lodes, and are often found cutting across them and sometimes longitudinally through them. Reefs of this type are being worked at the Ida H. and Augusta G.M.s.

Not many reefs of the second class, i.e., normal quartz reefs, are being worked in this district; a fair number occur, some of them being of very fair size. Some of the best types of this class are found at the northern end of the district on G.M.L. 1291 and 1095, near what was originally known as Crawford's Patch. These reefs occur in massive greenstone, and are of white, somewhat ironstained quartz; they are of fair size and can be traced on the surface for some distance; several small leaders run into these main lines of reef, and it has been in these and at their junction with the main lines that the gold has been got, the stone in the leader at the junction being usually "dollying" stone. The main reefs themselves, though fair sized and well defined as far as tried, are too poor to pay for working.

There are also a fair number of large sized quartz reefs occurring along the junction of the granites with the greenstones; these are, however, for the most part, short and irregular, and are apparently very low in their gold contents, as little or no work has been done on any of them.

*Alluvial Gold.*—Not much alluvial gold has been got in the district. A little was got on the western fall of the main ridge near the old British Flag G.M. The gold in this case was probably derived from small quartz leaders associated with the hematite-bearing lodes. Most of the alluvial has been got, however, at what was known as Crawford's Patch, half to three-quarters of a mile south-east of

Mount Crawford. Here a fair amount of dry-blowing has been done, but the gold appears to be nearly all worked out. It was got mostly at a depth of only a few inches, and has probably been derived from small quartz leaders both in the greenstones and the granitic rocks and from leaders associated with quartz reefs in the greenstones, such as those worked on G.M.Ls. 1291, 1095, and 1601.

*Water.*—Water is fairly plentiful throughout the district, and the supply is generally fresh, the town depending upon wells for its supply for domestic purposes.

*Timber.*—Timber of good quality is not plentiful, and is rapidly becoming exhausted.

### The Mines.

THE LANCEFIELD G.M.L. 806, etc.—This is the largest and most important mine in the district, and is situated some five miles north of Laverton townsite. At the time of my visit, the mine was equipped with a 50-head stamper battery, concentrators, and leaching and filter press plants. (*Photographs 2 and 3*). Owing, however, to difficulty in ore treatment, the use of the present plant is to be discontinued and a dry crushing and roasting plant to be installed in its place. This, it is hoped, will prove highly successful and give an impetus to mining generally throughout the district.

The workings are on a large banded quartz lode (Fig. 1) trending about north-east and south-west, and dipping at an average angle of about 40 degrees to the south-east. From an examination of the mine plans (Plate A.) it will be seen that, though a very considerable amount of stone has been taken out, the mine is still in its infancy, having only been opened up to a depth of 300 feet on the underlay. The ore body consists of banded and hematite-bearing quartz, presenting in the upper level almost the appearance of a normal quartz reef with a strongly marked laminated structure, apparently with fairly well defined walls, though the country is too decomposed and rotten to see much here. As the unoxidised and unaltered zone is reached it is seen that there are no hard and fast walls to the lode, but that it is encased on both sides by about 30 feet of greenstone schists, which, in places, approach in appearance very close to the lode proper. In the 300-foot level, the lode consists of alternating bands of quartz and altered schist, carrying a large percentage of arsenical pyrites, usually arranged in roughly parallel zones with the quartz. As a rule the quartz largely predominates, often to the complete elimination of the schist, having in these cases a banded dark grey appearance, frequently seamed with small veinlets of calcite; in other cases the schist predominates over the quartz.

EY.

PHOTO. 2.

*Bulletin 24.*



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Govt. Photo. Litho.

**Lancefield Gold Mine and Plant, Laverton.**







PHOTO. 3.

*Bulletin 24.*



on.  
Cyanide Vats, Lancefield Gold Mine, Laverton.

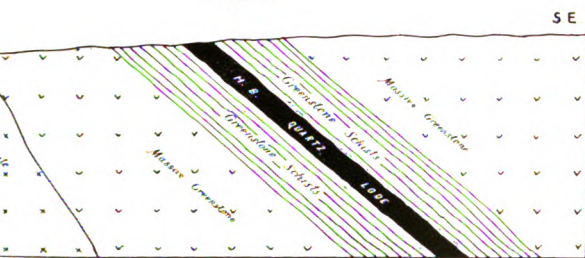
Govt. Photo. Litho.





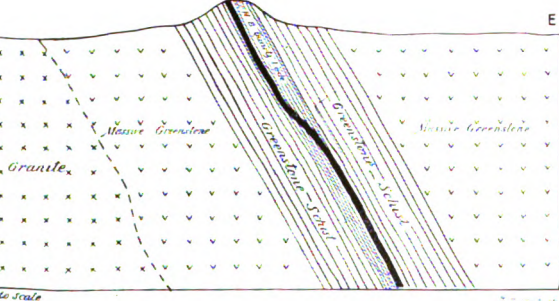


FIG 1.



SHewing MODE OF OCCURRENCE OF LODGE ON LANCEFIELD G.M.L. 806 LAVERTON DIST. MT MARGARET G. F.

FIG 2.



SHewing MODE OF OCCURRENCE OF REEF ON AUGUSTA G.M.L. 371 LAVERTON DIST. MT MARGARET G. F.







SKETCH SECTION OF AUGUSTA G.M.L. 371. LAVERTON MARGARET G.F.











there is no defined limit between the lode proper and schistose greenstone; the gold contents, too, usually at in these cases, being as a rule highest where there is present. The lode, generally speaking, has an average about 17 feet, though it varies a good deal on this, being as much as 25 feet in places in the bottom gain in the north face of the 200-foot level, it is down this, however, is exceptionally small. The gold contents the workings are remarkably uniform, and the shoot proved for over 1,000 feet in length, and its exact yet known. A reference to the accompanying plan show the sizes of the lode at the different levels. (The 100-foot level and the surface being taken from old only approximate.) The zone of oxidation stops a little feet level, there being a small percentage of sulphide in this level; below this the sulphides come in very heavily, for a great part of arsenical pyrites, this being the chief the treatment of the ore. A little graphitic schist is found on the walls of the lode, but it is very limited the original water level was probably the first (100 feet) vertical depth of about 60 feet. The supply is fresh. Faults cross the lode in a general east and west direction; but, do no harm, their throw being only a few feet. In of the workings, in the 200-foot level, the reef is cut by the intrusion of a granitic dyke; there is no sign 100-foot level, but it will probably be met with in the ings.

seen, on reference to the accompanying plan (Plate A.), still a very large quantity of stone available, even above level, and when the large amount of backs for every working is taken into consideration, it can easily be seen the difficulty of satisfactory ore treatment be overcome, and a long and prosperous future before this mine.

*Vancessfield G.M. Co., Ltd., G.M.Ls. 806, etc.*

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
.. ..	6,110.00	2,056.67	.33
.. ..	11,701.00	5,639.75	.48
.. ..	16,847.00	6,256.55	.37
.. ..	20,781.00	7,780.60	.37
.. ..	21,928.00	7,068.29	.32
.. ..	25,154.78	10,733.91	.42
.. ..	47,693.00	15,373.32	.32
al .. ..	<b>150,214.78</b>	<b>54,909.09</b>	<b>.36</b>

CRAIGGIEMORE, G.M.L. 592.—As can be seen from the accompanying plan (Plate B.) of this mine, a large amount of work of a somewhat irregular nature has been done. (*Photograph 4*). In all three different ore bodies have been worked, known respectively, as the Eastern, Middle, and Western; of these, the Eastern and Middle, in the bottom level, are apparently one and the same; the Western lies a chain or so farther to the west. These so-called separate lodes are apparently merely shoots of pay ore in the one large lode, the whole country here over a width of 150 to 200 feet consisting of a very much crushed and altered greenstone, carrying more or less gold throughout. Portions of this zone are more highly altered than others, and on the surface have the appearance of the usual hematite-bearing quartz lodes: a little below the surface, they become soft and consist apparently of weathered bands of schist and ironstone with more or less quartz; in some cases, when the quartz largely predominates, these bands assume a solid well defined character, in others again they are of a very sintery nature. Occasionally these bodies take the form of the typical compact banded hematite-bearing quartz lodes, in which cases their gold contents are usually slightly lower; as a rule, the best values are obtained in the sintery bodies. As may be expected, there are no hard and fast walls between these pay shoots and the enclosing schists, the whole being, as before stated, practically one large lode formation. At present there has not been sufficient work done to determine the exact size and relationship of the pay shoots, they are, however, very irregular; the western one has been proved for about 100 feet south and 200 feet north of the shaft, and is still going north; the extent of the other makes is not known.

The values in these shoots varies a good deal, a lot of the stone not being good enough to take out, and the workings are very irregular on this account, the stone simply being extracted where it has been found rich enough to pay for working; in the upper levels the stopes vary from 15 to 30 feet in width on all the ore bodies; in the lower level all the work is at present being concentrated on the western lode, which is being stoped out for a width of about 15 feet. The country and the ore bodies dip almost vertically, but the latter pitch fairly flat to the northward. The whole country is very soft and rotten all through the present workings, and just begins to get hard and settled at the 300-foot level, at which point a fair amount of sulphide begins to make its appearance in the stone. The ore bodies worked on this property are in every way similar to the hematite-bearing quartzites occurring all along the main ridge through this lease to Laverton, and it seems not unreasonable to presume that there are other payable bodies of stone along this line as yet undiscovered. Other bodies along the line have been worked on the British Flag lease, and also one or two other leases between Craggiemore and Laverton, but so far with not very satisfactory results.

GEOLOGICAL SURVEY.

PHOTO. 4.

*Bulletin 24.*



Photo., C. G. Gibson.

Govt. Photo. Litho.

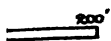
**Craiggie More Gold Mine, Laverton.**



E



E G.







*raiggiemore Proprietary, G.M.L. 592T, etc.*

Year.	Ore crushed.	Gold therefrom.	Average.
	Tons.	Fine ozs.	ozs. per ton.
.. ..	10.00	13.01	1.30
.. ..	205.00	171.93	.83
.. ..	1,020.00	296.53	.29
.. ..	9,260.00	3,641.24	.39
.. ..	14,200.00	5,070.67	.35
.. ..	14,000.00	4,652.08	.32
.. ..	13,700.00	4,382.42	.32
.. ..	14,769.00	3,958.60	.27
.. ..	18,152.00	*7,640.44	—
.. ..	<b>85,316.00</b>	<b>29,826.92</b>	<b>.35</b>

\* Includes 3,297.09 by cyanide.

A. G.M.L. 371.—This lease is situated about four miles of Laverton, and was once the property of the Golden Co.; it was abandoned by them after a good deal of been done on it, and recently taken up again by the ers. who, up to the present time, are doing very well the workings are on a quartz reef of the normal type, alongside and through a band of highly altered green- (Fig. 2), in which, on or near the surface, alteration so far that it has been converted into a typical banded ring quartz lode. At the surface the reef is on the foot- band, but cuts through it at about 240 feet and then hanging wall. The country on both sides of the reef e schist, all in a more or less altered state; at about belt of altered schist which forms the footwall of the remely hard, and continues so to the bottom of the (300 feet); this is evidently the continuation in depth site-bearing quartz lode seen on the surface, being here half-formed state, consisting of greenstone schist highly h infiltrated hematite and quartz. The country sur- e schists is, at the 300-foot level, very hard and massive, of a fine grained greenstone [6558], a section of which, the microscope, shows it to consist essentially of pale ende and triclinic felspar in small irregular lumps and hornblende occupying the greater part of the section, ion numerous small scattered grains of magnetite.

itself is not at all regular, and varies in thickness from d up to as much as six feet, which is its thickness in the f the 300-foot level; it has no well-defined walls, and irregular cracks and hollows in the schists. It dips. schists, at an angle of about 45 degrees to the east and e to the west of north; it does not, however, keep a very se, but twists about a little. A good deal of graphitic schist

is found on the footwall of the reef in the 300-foot level; this only occurs over a length of about 20 to 30 feet, and can be traced right to the surface, having an average thickness of 12 to 18 inches. The quartz is very clean and white, and very hungry looking; in places, however, it shows fairly coarse gold freely.

The present owners are working a rich shoot of stone near the north end of the bottom drive (Fig. 3). This shoot has been followed down by means of a winze to a depth of about 40 feet; the average width of the reef in this winze is about two feet and it shows coarse gold and telluride freely over a depth of about 25 feet; in the bottom of the winze it is smaller and much split and broken up. This shoot of ore at present being worked was cut in the 300-foot level, and here had a length of about four feet, this being just the top of the shoot, and dips to the north at a fairly flat angle. Some of the stone taken out was phenomenally rich, and showed, in addition to free gold, a thin white telluride, which an examination in the Departmental Laboratory proved to be Altaite (telluride of lead). This occurrence is interesting from the fact that this is one of the very few places in Western Australia, outside Kalgoorlie, from which an authentic discovery of telluride has been reported.

Water is not too abundant; it is, however, drinkable, and is also used for the boilers.

The mine is equipped with a 10-head battery.

The sketch section (Fig 3). showing approximately the amount of work done, is prepared from figures supplied, from memory, by the present manager, the existing underground plans not being available.

*Augusta, G.M.L. 371, late Golden Rhine G.Ms. G.M.Ls. 371 (777, 764, 1249).*

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	fine ozs.	ozs.
1897	..	..	..	50.00	167.20	3.34
1898	..	..	..	391.50	1,099.99	2.81
1899	..	..	..	1,774.00	1,904.07	1.07
1900	..	..	..	630.00	496.64	.78
1901	..	..	..	8,091.00	5,121.30	.63
1902	..	..	..	3,711.00	1,838.62	.49
1903	..	..	..	850.00	430.93	.53
1904	..	..	..	—	—	—
1905	..	..	..	834.00	1,659.43	1.98
Total .. ..				16,331.50	12,718.18	.77

BINDAN AND CORNUCOPIA, G.M.Ls. 1588, 1601.—These leases are situated about three and a-half miles north of Laverton town-site, and consist of two six acre-blocks, situated on a well-defined line of lode running about north-west and south-east. This line

FIG. 4.

E

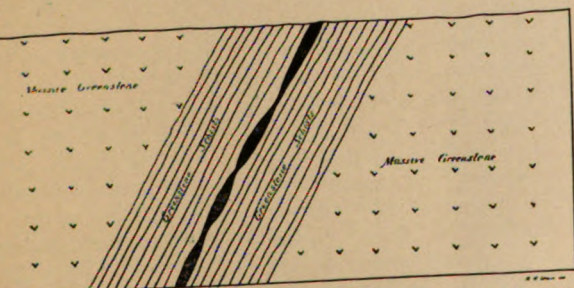


DIAGRAM - SHEWING MODE OF OCCURRENCE OF REEF ON LITTLE DORIS GML771 ERLITOUH, MMARGARET 6 F





ists of a belt of highly foliated greenstone schists some feet in width, and dipping steeply to the south. Though this belt of schist, numbers of irregular quartz in all directions; these vary in size from 1 to 12 inches, of the smaller ones often carry a big percentage of gold; many of them, however, are barren or close to it; small rich stone are often found at the intersection of the small at points where they coalesce with the larger; these are only dollying stone, but not much more than a few ounces obtained from them. On the Bindan lease an open cut made on this band of schist over practically its entire width, of about 12 to 14 feet, and for a length of some fifty yards, propose of working out the rich leaders and pockets, but of any importance beyond this has been done. On the especially near the southern end, there are two well sized lines of reef running through and parallel with on; these are of white quartz and are as much as two or three feet thick; they intersect near the centre of the lease and die out or so farther on. A little work has been done in these reefs, but they are too low grade to be of any use; a small rich pocket was found at the junction, one or two small pockets have also been found at the points at which small leaders run in these reefs; on the adjoining lease, most of the gold on this block has been obtained from small leaders, and has been obtained at a depth of less than 12 feet from the surface, this being the depth of most of the gold-bearing leaders cut out. A few chains of G.M.L. 1588 is a similar belt of schist traversed by small quartz leaders: a little work has also been done on it, but they do not appear to have been as rich as those in the other belt. A fair amount of dry-blowing has been done in these leases, and the gold has undoubtedly been shed from the leaders in these and similar belts of schist.

In 1905, the crushings from this lease (Cornucopia, G.M.L. 1588) yielded 15.00 tons for 39.08 ounces, giving an average of 2.60 ounces per ton.

G.M.L. 829, etc.—Next to the Lancefield, this is the most important mine in the district, and, as can be seen from the geological section (Plate C.), a very considerable amount of work has been done upon it. The workings are on a fair sized but not very rich quartz reef, which runs in and parallel to a belt of highly foliated greenstone schists. This belt of schists on the surface has been altered into a solid hematite-bearing quartz lode, which was worked for a considerable distance; this, however, is merely an illusion, as at the 100-feet level it has entirely disappeared. The schists are of a soft decomposed and iron-stained appearance, and contain occasional small seams of ironstone running through them. These ironstone seams are found on both sides of the reef and in close proximity

to it, often carry a small quantity of gold, but not sufficient to be payable. Small quartz leaders up to a couple of inches in thickness are often found traversing the schist, usually running parallel to them; these, though often auriferous, are usually too small and irregular to be of any value. In the lower levels these schists carry a considerable quantity of sulphide ore, and at the 300-foot level are several bands of solid massive pyrites up to two or three feet in thickness running parallel to the reef, one along the footwall and two others some 8 and 20 feet respectively to the east of it. These sulphide lodes are apparently merely replacements of the schists, and evidently correspond with the "ironstone bands" in the upper oxidised zone; they carry a little gold but not sufficient to render them of any value.

One or two augite-dolerite dykes cut across the reef and the surrounding schists in an east and west direction; the largest of these is about 600 feet north of the main shaft and some 20 feet in thickness, and is vertical. The reef is merely cut in two by these dykes and not thrown or displaced in any way; the stone, however, is usually of a little better grade in proximity to the dykes.

The reef itself is of clean white quartz, and, as can be seen from the accompanying section (Plate C.), has been followed for nearly 1,600 feet; it runs in a nearly north and south direction, and dips at an angle of about 60 degrees to the eastward; in size it is somewhat irregular, being as much as six feet in thickness in places, while in others it dies out to nothing, the quartz being replaced by schist which is practically identical with that forming the walls; this schist is itself of no value, but it is often seamed with small quartz veins, in which case it is usually sent to the battery; taking the reef right through, its average thickness is about two feet. The gold contents are not uniform over the entire length, the extent of the pay shoots being shown on the accompanying section of the workings; it will be seen from this section that the developments at the 400-foot level tend to prove the continuance at a depth of the northern shoot, and should the 500-foot level, when opened up, prove its further existence, it will mean a period of renewed prosperity for this mine.

The stone in the lower levels carries only a small amount of sulphides, these beginning to make their appearance at the 300-foot level; the limit of oxidation is not regular, being deeper on the north side of big greenstone dyke; there was also a much heavier supply of water on this (northern) side of the dyke. In the 400 foot level, a little zinc blende is found in the quartz, the gold contents being usually higher where this occurs. The water in the mine is salt, and water for boiler and cyanide and domestic purposes is obtained from a well at Mount Barnicoat, about two-and-a-half miles north.

The mine is equipped with a ten-head battery and cyanide plant. (Photograph 5.)



PHOTO. 5.

*Bulletin 24.*



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Govt. Photo. Litho.

**Ida H. Gold Mine and Plant, Laverton.**

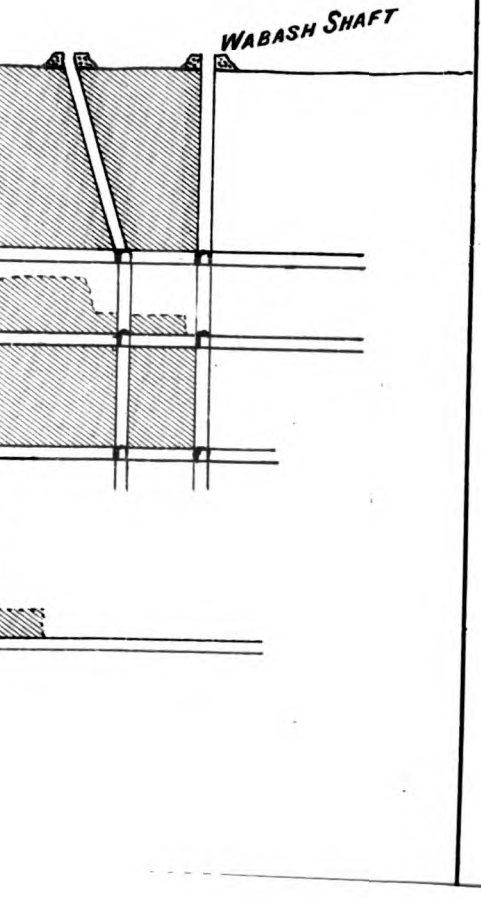


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Table showing the total gold yield from the Ida H. G.M., G.M.Ls.  
829, 846, 1219, 1310, 838.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1899	..	..	..	81.00	235.37	2.90
1900	..	..	..	30.00	49.76	1.66
1901	..	..	..	1,858.00	1,817.08	.97
1902	..	..	..	11,319.00	12,346.65	1.09
1903	..	..	..	13,017.00	12,856.44	.91
1904	..	..	..	14,610.00	12,369.91	.84
1905	..	..	..	16,713.00	11,902.52	.71
Total .. ..				57,628.00	51,577.73	.89

IDA H. CONSOLS, G.M.L. 1623.—Three shafts have been sunk on this property, one vertical and two underlay, all to a vertical depth of 130 feet; an underlay winze has been sunk to a further depth of 40 or 50 feet; the reef has been worked out from the 130 feet level to the surface for a length of about 110 feet, commencing from a point some 20 feet south of the south underlay shaft. A little work was being done at the north end of the bottom workings at the time of my visit. The reef, which runs along the hanging wall side of an "ironstone bar" hematite-bearing quartz lode, strikes about north and south and dips to the eastward at an angle of about 60 degrees; it is of clean white quartz, and averages from 6 to 15 inches in width; at the south end of the bottom workings it has pinched to a mere thread, but makes again farther on, as it has been worked on the adjoining property, the White Horse, to a depth of 130 feet, and apparently a good deal of work has been done on it here; these workings were, however, inaccessible at the time of my visit.

The country consists of greenstone schist, and is very soft and rotten. The water level is at about 130 feet vertically below the surface.

Table showing the Yield of the White Horse Reef.

Year.	Name and Number of Lease.			Gold crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
							Ore crushed.	Gold therefrom.	
				tons.	fine ozs.	ozs.	tons.	fine ozs.	ozs.
1902	White Horse, G.M.L. 854	...	...	87 00	36 97	55			
1903	Do.	do.	...	61 50	35 37	57			
1904	Do.	do.	...	29 00	23 04	75			
1902	Ida H. Consols, G.M.L. 1623 (1949)						157 50	104 28	66
	late Ida H. North Extended, 1949			111 00	164 81	1 48			
1903	Do.	do.	...	228 50	183 80	81			
1904	Do.	do.	...	52 00	14 90	29			
1905	Do.	do.	...	35 00	7 77	22			
							494 50	271 28	64
	Total .. ..			...	...	...	562 00	375 56	64

GREAT BEDFORD, G.M.L. 1042 (late Cock o' the North).—An extensive belt of greenstone schists runs on a bearing slightly west of north and east of south through this property and the adjoining ones, portions of it being altered into the typical hematite-bearing quartz lodes; these vary in width, on the surface, from a couple of feet to nearly a chain, and run with the schists, dipping with them at a steep angle to the westward. These lodes present on the surface a somewhat lenticular form and are very hard and compact, often rising in the form of low rough ridges, which can be traced across country in a more or less interrupted line for over a mile. This hard silicified form does not generally extend to any great depth, being to a great extent only a surface alteration, but at a comparatively shallow depth gradually gives place to soft altered and sometimes ironstained schist with occasional thin seams and stringers of quartz running through it; there is, however, one well defined hematite-bearing quartz lode continuing in depth; this is met with in the northern workings where it has a thickness of about 30 feet. All the workings on the lease are in this belt of schist, which in reality forms one immense lode, some parts of which have undergone greater alteration than others, and are higher in their gold contents. The workings consist of a main shaft, which at the time of my visit was sunk to water (200 feet), and from which a few feet of driving had been done at about the 100-foot level on a small body of quartz running parallel to the lines of foliation of the schists; several of these quartz leaders were cut in the shaft, and some of them carry very good values. Most of the work, however, has been done towards the north end of the lease, where several shafts have been sunk on the side of a large outcrop of hematite-bearing quartz. The shaft from which work was being done at the time of my visit was down 75 feet, and a drive had been put in at this level westerly for a distance of 140 feet; 60 feet in from the shaft a winze has been sunk a further 30 feet; this is on the western side of a hard compact hematite-bearing quartz lode ("jasper lode") where there is about eight feet of fairly good ore, consisting of schist highly impregnated with quartz in veins and masses, the quartz often being the full width of the ore body. A similar ore body, four to five feet wide, occurs on the eastern side of the "jasper lode," both being very similar to the main lode, differing only in the fact that they contain more clean quartz and less oxide of iron. A small amount of work has been done on both of these ore bodies.

The western portion of the main drive is in soft, much ironstained schist with a good deal of quartz coming in near the end, and carrying very fair values in places. The whole of this drive is, carried through one big lode consisting, as stated before, of more or less highly altered greenstone schist, portions of which have undergone greater alteration and are more highly impregnated with quartz than others, and it is in these portions that the best

ained, though the formation carries a little gold through-  
width.

is equipped with a Huntingdon mill and winding  
the time of my visit was handicapped by an inadequate  
; this difficulty, however, would probably be overcome  
ing of the main shaft.

uation of the Great Bedford line of lode is traceable  
tinuous line for over a mile northerly, and in one or two  
work has been done on it with fair success. On the Scot-  
k of the Walk), a good deal of work appears to have  
a large banded quartz lode, but, at the time of my  
ings had been abandoned and were inaccessible. A little  
was being done, and a small parcel of stone crushed  
isfactory results.

*Bedford, G.M.L. 1042 (late Cock o' the North).*

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
.. ..	37.00	91.09	2.73
.. ..	33.00	14.79	.44
.. ..	82.00	24.87	.30
1 .. ..	<b>152.00</b>	<b>130.75</b>	<b>.86</b>

*Walk, G.M.L. 1663 (late Scotland Yet, G.M.L. 1253).*

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
.. ..	115.00	47.72	.41
.. ..	45.00	15.29	.34
1 .. ..	<b>160.00</b>	<b>63.01</b>	<b>.39</b>

The following table, compiled from the official statistics, shows the total gold yield from the leases in that portion to the Laverton district mentioned in the accompanying report, up to the end of 1905:—

Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
Acrasia, G.M.L. 1616r. .. .. .	14.00	9.85	.70
Ajax, G.M.L. 828r (790r) .. .. .	57.00	57.43	1.00
Alma Mater, G.M.L. 1180r. .. .. .	631.00	680.92	1.07
Augusta, G.M.L. 371r .. .. .	16,331.50	12,718.18	.77
British Admiral, G.M.L. 723r .. .. .	10.00	18.43	1.83
British Empire, G.M.L. 1431r (1396r) .. .. .	199.50	120.83	.60
British Flag, G.M.Ls. 1302r (358r) .. .. .	93.00	*514.35	—
Broken Pledge, G.M.L. 1513r .. .. .	20.00	4.17	.20
Cock of the Walk, G.M.L. 1663r .. .. .	160.00	63.01	.39
Cornucopia, G.M.L. 1601r .. .. .	15.00	39.08	2.60
Corio, G.M.L. 1439r .. .. .	7.00	4.08	.58
Craiggiemore Proprietary, G.M.Ls. 592r, etc. .. .. .	85,316.00	29,826.92	.35
Dream, G.M.L. 825r .. .. .	210.00	† 593.12	—
Emerald, G.M.L. 1486r .. .. .	34.00	22.09	.64
Enniskillen, G.M.L. 1453r .. .. .	96.00	17.09	.18
Federal Flag, G.M.L. 985r .. .. .	20.00	10.17	.50
Flintlock, G.M.L. 1192r .. .. .	123.00	69.88	.56
General Wabash, G.M.L. 838r .. .. .	100.00	288.72	2.89
Golden Pinnacle, G.M.L. 1459r .. .. .	211.00	55.28	.26
Great Bedford, G.M.L. 1042 .. .. .	152.00	130.75	.86
Great Britain, G.M.L. 563r .. .. .	10.00	9.26	.93
Ida H. G.M., G.M.Ls. 829r, etc. .. .. .	57,628.00	51,577.73	.89
Ida H. West G.M.Ls. 1394r (1006r) .. .. .	503.00	358.44	.71
Ida H. Consols, G.M.L. 1632r (1249r) .. .. .	424.50	271.28	.64
Just in Time, G.M.L. 1159r .. .. .	50.00	62.35	1.24
Kiora, G.M.L. 902r (793r) .. .. .	366.00	357.09	.97
Kuranin Reefs, G.M.L. 1308r .. .. .	20.00	39.82	1.99
Lady Beatrice, G.M.L. 1615r .. .. .	91.00	34.57	.38
Lady Hopetoun, G.M.L. 1098r .. .. .	7.00	2.68	.38
Lady Julie, G.M.L. 1605r .. .. .	8.00	16.00	2.00
Lancefield, G.M., G.M.Ls. 806r, etc. .. .. .	150,214.78	54,909.09	.36
Laverton, G.M.L. 1490r .. .. .	39.00	11.69	.30
Lights of Home, G.M.L.* 1339r .. .. .	170.50	214.23	1.25
Lloyds, G.M.L. 929r .. .. .	21.00	11.05	.52
Lord Hopetoun, G.M.L. 1095r .. .. .	25.00	2.86	.14
Little Queen, G.M.L. 1506r .. .. .	18.00	46.07	2.55
Maryboro., G.M.L. 1161r .. .. .	20.50	17.44	.85
Mystery, G.M.L. 1067r .. .. .	145.00	145.78	1.01
Menzies Golden Rhine, G.M.s., G.M.Ls. 475r, 660r, 718r, etc. .. .. .	652.00	359.12	.55
Nous Verrons, G.M.L. 1214r .. .. .	176.50	157.33	.89
Pat's Find, G.M.L. 1468r .. .. .	10.00	21.97	2.19
Rescue, G.M.L. 1518r .. .. .	10.00	3.40	.34
Rose, G.M.L. 1373r .. .. .	643.50	505.61	.78
Sons of Toil, G.M.L. 1309r .. .. .	138.00	92.50	.62
St. Alban's, G.M.L. 1479r .. .. .	171.00	95.02	.55
Sunny Hill, G.M.L. 1082r .. .. .	87.00	72.52	.83
Toby, G.M.L. 1426r .. .. .	9.50	42.07	4.43
Warrior, G.M.L. 1424r (1159r) .. .. .	30.00	34.33	1.14
Westella, G.M.L. 1476r .. .. .	30.00	45.52	1.52
Wooloomooloo, G.M.L. 1368r .. .. .	17.00	69.07	4.06
White Horse, G.M.L. 854r .. .. .	157.50	104.28	.66
Sundry Claims .. .. .	963.00	708.22	.73
Laverton State Battery .. .. .	46.50	346.19	—
District Generally .. .. .	..	† 58.71	—
<b>Total .. .. .</b>	<b>316,702.78</b>	<b>\$ 155,987.93</b>	<b>.49</b>

\* Includes 267.32ozs. doilled and specimens.  
specimens.

† Alluvial.

† Includes 68.98ozs. doilled and  
Exclusive of alluvial.



PHOTO. 6.

*Bulletin 24.*



Govt. Photo. Litho.  
typical Granite "Breakaway," Burtville.



## Burtville.

(With a Geological Sketch Map, Plate IV.)

Centre is situated twenty-four miles south-east from and a cleared surveyed road connects the two places. The road passed over by this road is mostly flat, with occasional outcrops of massive greenstone of the usual type, and one or two outcrops of hematite-bearing quartz similar to that occurring in the townsite of Laverton. At Burtville itself the country is the exception of a few greenstone ridges at the north end of the area examined and the broken edge of the tableland a few miles to the east. The greenstone ridges are numerous towards the northern end of the district, but are small and at best occupy only a comparatively small area in the neighbourhood of the townsite, and to the east, south-east, of it, the country for several miles is practically a dead level covered with a varying thickness of recent superficial deposits and it is on this plain that most of the working shows are to be seen. The only breaks in it are in the neighbourhood of the Rock of Ages, and Mikado leases, where there are low ridges of greenstone and greenstone schist.

The rocks of this district consist of both greenstones and granites, the greenstones being mostly massive and consisting of a hornblende of the usual type, one specimen [6546] of which is, seen under microscopic examination, to be a holocrystalline rock, consisting of hornblende and triclinic felspar in about equal proportions together with a little ilmenite, this latter being for the most part altered into leucoxene; the felspars are mostly in the form of prismatic crystals and are considerably clouded from the effects of alteration products; the hornblende is in large blocks and lumps somewhat chloritised in parts, and contains tremolite and actinolite.

There appears to be a considerable development of schists near the contact of the greenstones with the granite, but owing to the recent deposits which overlies the greater part of the district, the nature of these cannot be ascertained, and they can be seen only over one or two small areas, principally in the neighbourhood of the Carib lease. These greenstones are also traversed by two small belts of banded and hematite-bearing quartz; however, they are usually of no length or continuity, the largest of them is at the Rock of Ages and just to the east of it.

Sedimentary rocks appear to be of two distinct ages, and consist of a body forming the great sandy tableland commencing about five miles east of the townsite and continuing easterly to the western side of this tableland generally has more vertical cliff faces ("breakaways") (Photograph 6) rising 50

to 100 feet above the plain; the junction with the greenstones is usually half to one mile west from these breakaways, and appears to run on a general bearing slightly west of north and east of south.

The second body of granite is situated to the east of the townsite, and occupies a roughly circular area of about a mile in diameter; with the exception of one small area on the Maori Chief lease, it is entirely hidden beneath a varying depth of recent detrital deposits. From the scanty evidence available it would appear that this body of granite is intrusive into the greenstones which surround it on all sides, and it appears to have been subjected to the same stresses and strains as these rocks, the foliation, when such occurs, in the two classes being the same and the reefs generally parallel and sometimes continuous from one class to the other. A section of this granite shows it to be a biotite variety too much altered and weathered for satisfactory examination; the biotite, which is not very abundant, is in small flakes throughout the section, and is mostly altered to talc and a greenish chloritic material; the felspars are in large crystals and plates, but are clouded and altered almost beyond recognition.

These granitic rocks are occasionally intersected by basic (dolerite?) dykes, which are met with in the workings and not being visible on the surface; one cut in the workings of the Prior Right, G.M.L. 1536, is said to have carried a little gold.

Considerable weathering and alteration has taken place both in these rocks and in the greenstones, and they are very soft and easily worked even for some distance below water level.

Several fairly extensive deposits of laterite (ironstone conglomerate) are found overlying the greenstone in places; one of these, a little to the east of G.M.L. 1423 (Eureka), though small, is apparently of very high grade.

It is within the area of granitic rocks that most of the payable quartz reefs are found, and it is in this respect that Burtville differs from most of the other known mining centres of Western Australia.

The quartz reefs are almost invariably small, but they make up for this by often being of exceptional richness; they are usually of clean white—sometimes blue—quartz, and generally vary from 6 to 12 inches in thickness, often extending longitudinally, however, for a considerable distance. They are fairly numerous both in the granitic area and in the greenstones, but throughout the greater part of the district, owing to the covering of recent detrital deposits, are seldom found outcropping; they are found by picking up "floaters" on the surface and subsequent deep costeening or sinking and cross-cutting across the supposed line of the reef, the soft nature and good standing quality of the country generally rendering the latter method the more satisfactory.

The occurrence of gold throughout the reefs is not regular, neither are the reefs themselves uniform in size, often pinching out to a mere thread and then making again into a body of stone 12 or 18 inches in thickness, these bunches usually being richer than the narrow parts of the reef, which are often almost free from gold; as a rule also, these bunches carry their size down vertically, the pinching being only lateral.

The richness of the reefs and the soft easily workable nature of the country render the district an ideal one for the prospector, but the reefs are too small to be of any value to large companies; a large number of them which are yielding good profits under present conditions, *i.e.*, above water and in soft country, will probably fail to do so when hard country is reached as, though the reefs appear likely to live to a considerable depth, the values are almost certain to drop considerably as soon as the hard settled country below water is reached, and in the case of many of the six-inch reefs at present worth two to three ounces, this fact is likely to prove fatal, for a six-inch two ounces reef in soft "auger" country is a very different thing to the same reef in hard, solid granite; however, as one or two of the reefs have already been worked to a depth of 150 feet without the country becoming uncomfortably hard, there is, at the worst, still a good length of life in front of mining the Burtville reefs.

The district as a whole is well watered, the supply being plentiful and of excellent quality except at the extreme south end, where it is unfit for drinking purposes.

Timber is still fairly plentiful, but consists only of Mulga, some of it, however, of very fair size.

The following is a brief description of the principal mines working, as they appeared at the time of my visit (Oct., 1904).

### The Mines.

WANDERER AND WANDERER SOUTH, G.M.Ls. 1011, 1413.—A good deal of work has been done on these leases and the workings were the deepest in the district, the main shaft being down 200 feet vertical with north and south drives at this level; these workings, however, were abandoned at the time of my visit and were inaccessible. The reef worked was of white quartz, and was said to have averaged about two feet and to have been very bunchy; the shoot of gold had an average width of about 50 feet and dipped at a fairly flat angle to the south; the gold is said to have given out altogether a few feet below water level, *i.e.*, at about 150 feet, though the reef itself is still going down strong in the lower levels.

At the date of my visit (October, 1905) a little prospecting work was being done near the north end of the reef; a shaft is here being sunk on the reef, which is about  $2\frac{1}{2}$  feet in thickness but of low grade; it is hoped in this shaft to pick up the continuation of a small rich shoot which had been worked on the surface. The reef is fairly

well defined, and can be followed on the surface through the two leases for a distance of 10 or 12 chains; it runs almost due north and south and dips at an angle of about 75 degrees to the east. The country is a fairly fine-grained massive greenstone, very soft and rotten down to water level, but getting hard and settled in the bottom of the old workings.

*Wanderer South, G.M.L. 1011.*

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
1901 .. .. .	180.00	410.89	2.27
1902 .. .. .	207.75	419.35	2.01
1903 .. .. .	420.90	938.47	2.22
1904 .. .. .	242.00	93.38	.38
1905 .. .. .	72.00	58.10	.80
Total .. ..	112.265	1,920.19	1.71

*Wanderer, G.M.L. 1413.*

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
1904 .. .. .	65.00	69.91	1.67

TREBLE HANDED, G.M.L. 1634.—On this lease a good deal of work has been done on a small but exceptionally rich quartz leader running about north and south and dipping to the west at an angle of about 80 degrees. Several shafts have been put down on it, and the leader stoped out from the 150-foot level (water) to the surface for a considerable length; these workings were, however, inaccessible. The present owners are sinking a new main shaft with the intention of working the leader below water, they are now down 185 feet. The leader is said to have averaged not more than two inches, but to have been very regular and to have maintained its value well. The country is greenstone, and is very soft and rotten even at the bottom of the present main shaft. The water supply is fresh.

*Treble Handed, G.M.L. 1634T (1350T) (1108T).*

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
1900 .. .. .	7.00	44.67	6.38
1901 .. .. .	27.00	93.57	3.47
1902 .. .. .	35.50	233.04	6.56
1903 .. .. .	65.50	531.90	8.12
1904 .. .. .	29.00	68.20	2.35
1905 .. .. .	21.00	61.17	2.91
Total .. ..	185.00	1,032.55	5.58



**TEMPUS, G.M.L. 1068.**—The main reef on this property runs about 5 degrees east of north and dips at a steep angle to the west ; it is of somewhat ironstained quartz and very irregular, having an average thickness of 6 to 8 inches, but often pinching out to a mere thread ; the larger makes of stone are not regular and frequently pinch out vertically as well as laterally ; in the bottom level it is fairly continuous and regular, varying from 6 to 8 inches, and appears to be going down well underfoot. The most irregular portion of the reef is close to the main shaft, where it is much broken, and for a short distance runs almost flat, and takes a fairly sharp turn to the westward for a short distance. A couple of chains south of the main shaft, a second reef comes in from the eastward and joins the main one. Not much work has been done on this, but as far as opened up it is exactly similar in character to the main one. There is no definite shoot of gold in the reef, the values being fairly regular ; the best stone was, however, obtained from the stopes above the bottom level below water, this stone yielded about 10ozs. per ton. The country is a fine-grained massive greenstone, but is very soft and decomposed even in the bottom workings.

Water was met with at 100 feet vertical depth, and is fresh and drinkable ; the supply is not very heavy, and comes in principally along the walls of the reef.

The principal workings consist of a main vertical shaft sunk to a depth of 160 feet, at which level drives have been put in along the reef for 160 feet south and 110 feet north, and the whole of this block stoped out to the surface, with the exception of the last 30 feet of the north drive, from which the stopes were only carried up 30 feet, when the reef cut out. Several underlay shafts have also been put down on the reef to water, and a little work has been done from them, but they are not in use now.

*Tempus, G.M.L. 1068.*

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	fine ozs.	ozs.
1901	..	..	..	180.00	769.07	4.26
1902	..	..	..	132.50	495.83	3.74
1903	..	..	..	235.00	611.99	2.60
1904	..	..	..	270.00	364.75	1.35
1905	..	..	..	170.00	1,000.76	5.88
Total	..	..		967.50	3242.40	3.28

**NIL DESPERANDUM, G.M.L. 1044.**—A considerable amount of scattered work has been done on this lease ; a number of shafts have been sunk near the north-east corner and a good deal of work done on a number of small quartz leaders, some of which were said to have been exceptionally rich ; these workings had, however, been abandoned and were inaccessible at the time of my visit. The



present workings are situated near the centre of the lease, and are on a small quartz reef running almost due north and south and dipping steeply to the west; on this a shaft has been sunk about 50 (1) feet, and drives put in 110 feet north and 40 feet south along the reef, and the whole of this block stoped out to within about 30 feet of the surface. The reef, as usual, is "bunchy," varying in thickness from a mere thread up to nearly two feet, the average being about 10 or 12 inches; the lenses vary, one being over 60 feet in length, and having an average thickness of nearly two feet, but carry their size well vertically; they pitch slightly towards the south. The footwall is very good and well defined, the hanging wall not being so regular, and it is the irregularities of this wall that cause the pinchings in the reef. A new main shaft is now being sunk to water level a chain or so north of the present workings, and a party of tributers are doing a little prospecting work about five chains farther north.

The country is a soft rotten granite, very easily worked and good standing ground.

*Nil Desperandum, G.M.L. 1044 (760).*

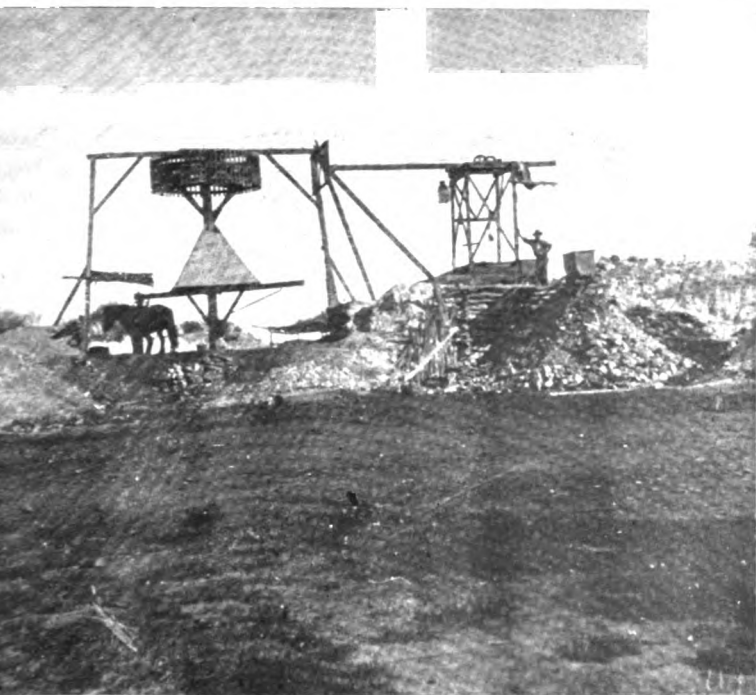
Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
1897 .. .. .	15.00	14.14	.94
1899 .. .. .	6.50	33.41	5.13
1900 .. .. .	24.00	90.35	3.76
1901 .. .. .	22.50	63.82	2.83
1902 .. .. .	70.00	379.48	5.42
1903 .. .. .	167.00	401.03	2.40
1904 .. .. .	160.00	377.07	2.35
1905 .. .. .	510.00	1,158.94	2.27
Total .. .. .	975.00	2,518.24	2.58

AWAY FROM HOME AND SAVAGE CAPTAIN, G.M.Ls. 1041, 1089.—(Photograph 7). These two leases are in the hands of the same owners, and are working on what is practically the one line of reef. Most work has been done on the Away from Home lease, where three makes of stone have been worked; these consist of separate parallel lenses, each looking northward, lying to the westward of the other, the southern end of one block apparently lying directly across from the northern end of the other; and may be different reefs or may be the same reef faulted over, there not being sufficient work done on any of them to definitely decide this point; it is more probable, however, that they are separate parallel reefs. The most southern block appears to have been worked right out, and was abandoned. On the next block the present working shaft is down 100 feet, and a drive 50 feet in length has been put in at this level, and a block 20 feet high stoped out along its whole length; a block 15 to 20 feet long has also been stoped out from the 50 feet level

L SURVEY.

PHOTO. 7.

*Bulletin 24.*



H. Gibson.

Govt. Photo. Litho.

**Savage Captain Gold Mine, Burtville.**





to the surface. On the next make of stone the shaft is down 100 feet, and 50 feet to 60 feet of driving have been done at this level, but little or no stopping. On the northern shoot, which is on the Savage Captain lease, the main vertical shaft is down 140 feet. At the 100 foot level, a block of stone 130 feet in length has been stoped out, north of the shaft, up to the 100 foot level, and the level continued another 40 feet north, while it has also been carried 65 feet south of the shaft. Water level in these workings is 100 feet, and bailing is being carried on from the bottom level at the rate of about 1,200 gallons per day, the water being fresh. The size of these shoots varies from a few inches up to a little over two feet; they underlie steeply to the west and pitch slightly to the south; the quartz is clear and white and somewhat glassy in places. The country rock is granite, and is very soft and easily worked down to water level, but below this in the northern workings it is commencing to get very hard and settled.

*Away from Home Leases, G.M.Ls. 1041, 1087.*

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	fine ozs.	ozs.
1900	..	..	..	45.00	432.13	9.60
1901	..	..	..	279.50	1,177.09	.42
1902	..	..	..	31.00	59.11	1.90
1903	..	..	..	215.00	229.65	1.06
1904	..	..	..	386.00	966.20	2.50
1905	..	..	..	461.00	656.58	1.42
Total	..	..	..	1417.50	3520.76	2.48

*Savage Captain, G.M.L. 1089.*

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	fine ozs.	ozs.
1901	..	..	..	84.00	282.25	3.36
1902	..	..	..	134.00	440.51	3.28
1903	..	..	..	394.70	1,598.90	4.05
1904	..	..	..	494.50	1,340.82	2.71
1905	..	..	..	408.00	1,043.55	2.30
Total	..	..	..	1515.20	4706.03	3.10

MAORI CHIEF, G.M.L. 1048.—The main workings on this property are at a depth of 180 feet; this being the greatest depth to which work has been carried within the granite area. Some very rich stone is said to have been taken out of these workings, but they had been abandoned owing to the decreased values of the reef in the hard country in the bottom workings. The workings were flooded, and were, therefore, inaccessible at the time of my

visit; the country was soft and easily worked to water, but below this began to get very hard, and in the bottom workings consists of a very hard compact massive granite.

At present a little prospecting work is being done at the south end of the block, and a shaft is being sunk with the hope of picking up a second rich shoot; this shaft, however, was only down about ten feet at the time of my visit, and had not got through the surface capping of recent deposits.

These are the only workings down into the hard settled country in the granite area, and the fact that the gold values become too poor to pay in this hard country, though not conclusive, is certainly a point against the long life of the Burtville reefs.

*Maori Chief, G.M.L. 1048.*

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	fine ozs.	ozs.
1900	..	..	..	24.00	116.75	4.86
1901	..	..	..	50.00	261.69	5.23
1903	..	..	..	99.60	676.52	6.79
1904	..	..	..	88.00	257.30	2.92
1905	..	..	..	73.00	372.22	5.10
Total	..	..	..	334.60	1684.48	5.03

PRIOR RIGHT, G.M.L. 1536.—The original workings on this block were at the north end of it on a small quartz leader running nearly due north and south and dipping at an angle of about 80 degrees to the west; this leader has been worked out to a depth of about 80 feet to the point at which it was cut off by a basic dyke, which runs about north-west and dips south-west across the leader at a comparatively flat angle.

This dyke has weathered into a soft reddish "pug," which is said to carry a little gold over its full thickness, about fourteen feet, while its values in close proximity to the point at which it is struck by the leader are said to have been pretty high; so far no attempts have been made to work this dyke, as owing to its "puggy" nature it is not amenable to ordinary battery and leaching treatment. The main leader is said to have been from 1 to 3 inches in thickness, and to have carried very high values; it is faulted off at the south end and has been worked completely out above the dyke, but no efforts were made to pick it up below; the workings on it were abandoned and were inaccessible. At the time of my visit a little work of a prospecting nature was being done some three chains to the east of the old workings, where a shaft had been put down about 50 feet, and had cut through the dyke; a couple of small leaders were cut in this but they were not good enough to pay. There are a number of small leaders through the lease, but they are mostly too small or too poor. The country is a very much weathered granite, and is very soft and easily worked.

ing 1905, this lease crushed 14.00 tons of ore for a yield of 14.00 fine ounces; being at the rate of .36 ozs. per ton.

GOLDEN BELL, G.M.L. 1553.—The reef on this property is about 100 feet in length and most continuous of those so far worked within the area; it runs almost due north and south, dipping at an angle of about 60 degrees to the west, and has been proved for a depth of over 20 chains. Like all the reefs in the district, it is irregular and "bunchy," varying in size from a mere thread in places to as much as two and two and a-half feet, and averaging 12 inches right through; the lenses of stone vary in length from 10 to 50 feet, and run pretty well vertically and carry their weight well; the stone is fairly uniform in its gold contents throughout the whole length of the workings, and, if anything, is better at water level, where it also carries a fair percentage of gold. The walls of the reef are clean and well defined; the stone is a very soft decomposed granite, very easily worked, and is well, and is still soft in the lowest workings (water level). It has been met with at 100 feet, and is fresh and drinkable. Near the south end of the lease, the reef appears to have been cut off by a fault running north-east and south-west, and no traces of it have been picked up south of this.

A good deal of work has been done on this block, and several shafts have been sunk to water level; from the presnet working about 220 feet of driving has been done north and 30 feet south of the 120 feet (U.L.) level—100 feet vertical; stoping has been carried along the whole length of the north level to within 100 feet of the surface, no stoping has been done to the south. In addition to these workings, a small party of tributaries are sinking prospecting shaft somewhat nearer the southern boundary.

In the adjoining block to the north (the Golden Bell North, G.M.L. 1566), a good deal of work has also been done on the same scale down to water level. In these workings it has exactly the same characteristics as in the Golden Bell lease, and averages about the same yield.

*Table showing the Yield of the Golden Bell Reef.*

Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
				Ore crushed.	Gold therefrom.	
	tons.	fine ozs.	ozs.	tons.	fine ozs.	ozs.
Bell, G.M.L. 1553r ...	48.00	223.52	4.65			
do. ...	930.50	3,342.66	3.59			
				978.50	3,566.18	3.64
Bell North, G.M.L. 1566r ...	92.50	341.83	3.59			
do. ...	232.75	367.75	1.58			
				325.25	709.58	2.15
Total ...	...	...	...	1,303.75	4,275.76	3.29

**CREMORNE, G.M.L. 1592 (1494).**—This property is situated about half-a-mile north-east of the Golden Bell, and on it a large amount of work has been done in the past, on a quartz reef running north and south and dipping to the west. This reef appears to be on the junction of the granite with the greenstones; there are no outcrops, the whole locality being covered with a considerable thickness of recent deposits, and the stone in the dumps is too rotten and decomposed to form any definite conclusion as to what it has been, but the north end of the reef appears to be in greenstone, while the south is in granite. The reef is said to have been larger and the average to have yielded some very rich stone. There was a ten-head battery on this lease at one time, but it was removed about eighteen months ago; this being the only lease in this district besides the Sons of Westralia on which a battery has been erected.

*Cremorne, G.M.L. 1592 (1494), (1034).*

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	fine oz.	ozs.
1900	..	..	..	70.00	228.61	3.26
1901	..	..	..	58.50	108.11	1.84
1904	..	..	..	52.50	34.58	.65
1905	..	..	..	7.00	10.49	1.50
Total	..	..	..	188.00	381.79	2.04

**MAXIM, G.M.L. 1384.**—This property is situated about a mile and a-half north-east of Burtville townsite, and is outside the granitic area; the country rock being a fairly fine-grained massive greenstone very much decomposed. The reef runs a little north of north-west, and dips to the west; it is traceable for about twenty chains, and appears to have been considerably larger than those in the granite. Several shafts have been sunk, and a good deal of work has been done on the property, but it was lying idle at the time of my visit. Up to the end of 1905 164.90 tons of stone had been crushed from this lease for a yield of 141.81 fine ozs., being at the rate of .86ozs. per ton.

**THE BROTHERS, G.M.L. 1054.**—The workings on this lease are also situated in greenstone country, but the reef is small and has exactly the same characteristics as those in the granite, consisting of a series of lenses of varying length, all pitching to the south at a fairly sharp angle; these lenses are generally connected by a small vein of quartz, but often there is only a "face"; they vary a good deal in size, those at the south end of the workings being almost two feet in one or two places, though the average size is about eight inches. The general trend of the reef is eight degrees east of north, and it has a dip of about 75 degrees to the west; at the south end there is a second parallel leader about 14 feet to the west, this however, being



short length; both reefs are crossed by a third small east and  
ader which yielded small pockets of rich stone at its junction  
e others, and in the part of it between them. The country  
imity to the reef is a very soft rotten greenstone schist, foliated  
to the strike of the reef, but turning into a massive variety  
0 feet to the west of it. It seems not unreasonable to presume  
a little more cross-cutting was done across this belt of schists,  
akes of stone parallel to the present line would be picked up.

good deal of work has been done on the lease, and a number  
s have been sunk to water (70ft. v.d.) between which level  
e surface a block 400 feet in length has been worked out. The  
owners are now working below water level, and have got  
ain shaft down 140 feet; a drive has been put in south along  
f at the 125 feet level for a distance of 140 feet, but little or  
ing has been done; the shoot of gold worked in the upper  
s dipping slightly south, and this bottom level is being pushed  
ick it up; so far the values in it are not too good.

water comes in principally along the footwall of the reef  
o very strongly along a fault some 12 to 15 feet to the west of  
f; it is somewhat brackish but is good stock water.

*The Brothers, G.M.L. 1054.*

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	fine ozs.	ozs.
00	..	..	..	28.00	73.89	2.64
01	..	..	..	82.00	292.37	3.56
02	..	..	..	260.50	342.75	1.31
03	..	..	..	108.00	156.83	1.45
04	..	..	..	13.00	6.66	.51
05	..	..	..	24.00	50.55	2.10
Total				515.50	923.05	1.79

STERY, G.M.L. 1664 (1563).—On this lease a good deal of  
has been done on a small quartz reef which runs north and  
and dips at a fairly steep angle to the westward. This reef  
s of a series of small irregular lenses of stone varying up to 30  
length, and having an average thickness of about 8 inches;  
enses have a decided pitch to the north but do not carry their  
well; the distance between them varies, but their is generally  
vein of quartz connecting them. The country rock is a green-  
chist, very soft and rotten but a good deal of siliceous ironstone  
on the footwall, mostly in irregular bunches, and is very hard  
compact and, so far, practically free from gold.

water was struck at a vertical depth of 70 feet, and is salt.  
l underlay shafts have been sunk to water (90 feet U.L.), and  
deal of irregular disconnected work has been done on the reef  
n this lease and on the adjoining one on the north.

*Mystery, G.M.L. 1664 (1563).*

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	fine ozs	ozs.
1904	..	..	..	126.00	193.83.	1.53
1905	..	..	..	28.00	25.38	.70
Total				154.00	219.21	1.42

KARRIDALE, G.M.L. 1010.—Two lines of reef have been worked on this property, but most of the work has been done on the southern one which is by far the richest, and also the more regular. The northern reef, which runs on a bearing of 240 degrees and dips at a fairly flat angle to the north-west, is very irregular in size, varying, within a few feet, from a few inches up to two or three feet in thickness; the shoot of gold worked is said to have been about 50 feet in length and to have cut out at a depth of 60 feet. Work is now proceeding on this reef at a depth of 70 feet, where a drive is now being put in southerly along the reef in the hopes of picking up another shoot. The reef at the south end runs on a bearing of 220 degrees, and dips at an angle of about 60 degrees to the north-west; it is a little more regular than the other, but is smaller, its average size being about twelve inches, getting smaller towards the southern end. Two shoots of gold have been worked; the northern shoot was about 90 feet long at water level, and ran out to a point a few feet below the surface; the reef in this was bigger than usual, being from two to three feet six in one place—near the surface; these big makes of stone were not much good right through, the best values being obtained on the footwall side, the reef is smaller and more regular along the bottom level, being from 8 to 12 inches. The southern shoot, which is the one being worked at present, is about 100 feet in length at water level, and tapers to a point at the surface the same as the other; it has been worked out to within about 30 feet of the surface, and the best stone was got along water level; the stone is much smaller in this shoot, being from 1 to 12 inches, the lenses or "makes" of stone being very irregular; the footwall is clean and regular, the bunches being caused by irregularities, principally in the hanging wall; the reef appears to be going down well under foot at the water level, where it also carries a considerable percentage of pyrites. As the two shoots are only separated by a few feet of blank stone at water level, and are making towards each other, there should be a good length of pay ore when the next level is opened up. The country is greenstone schist, very much weathered and decomposed; the reefs run and dip with the foliation of the schists; on the footwall of the reef, these schists have been very highly altered over a width of four to six feet, and converted into a band of siliceous ironstone, mostly very hard and compact, locally known as "jasper"; this band occasionally carries a little gold, but not sufficient to make it payable.

A second of these bars runs on a north-westerly bearing across about the centre of the lease, probably marking an old line of fault, which, on the surface, appears to have cut off the southern reef, and it may be that the northern one is merely the extension of this reef faulted over. Water was struck in the workings at about 80 feet (v.d.) and is salt.

The extension of the southern reef is also being worked on the north end of the adjoining block on the south (the Castlereagh, G.M.L. 1598) where a good deal of work has been done on it to water level.

*Karridale, G.M.L. 1010.*

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	fine ozs.	ozs.
1900	..	..	..	59.00	241.02	4.08
1901	..	..	..	143.00	398.35	2.78
1902	..	..	..	166.00	387.33	2.33
1903	..	..	..	687.33	711.93	1.03
1904	..	..	..	282.25	1,000.25	3.54
1905	..	..	..	291.00	2,143.71	7.36
Total .. ..				1,628.58	4,882.59	2.99

BOND'S FIND, G.M.L. 1019.—All the work on this lease has been done at the north end on a small irregular quartz reef striking about north-north-east, and dipping at a very flat angle to the westward. A number of shafts have been sunk on this reef to depths varying from 40 to 75 feet, and a good deal of irregular and disconnected work has been done on it. The reef dips westerly at an angle of about 15 degrees, but turns over sharply and forms several sharp sigmoidal curves northerly, and, altogether, is very irregular and broken. The size of the reef varies considerably, the average being only a few inches, though bunches up to 18 inches have been worked, whilst again it will pinch into a mere thread for some distance. The length of the shoot of gold worked was about 200 feet, but the stone was not quite uniform over this length, some of it being very good whilst some was rather poor. The country is decomposed greenstone, and appears to be intruded by several greenstone dykes, though it is so rotten and weathered that it is almost impossible to definitely recognise the presence of these. ¶

No work has been done below water level (75 feet v.d.). ¶ ¶ ¶

A similar class of reef to this has been worked on the adjoining lease to the east, the Roscommon.

*Bond's Find, G.M.L. 1019.*

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
1899 .. ..	11.50	34.04	2.96
1900 .. ..	47.50	112.62	2.37
1901 .. ..	123.00	342.84	2.78
1902 .. ..	129.00	500.67	3.88
1903 .. ..	278.00	377.83	1.35
1904 .. ..	194.00	219.84	1.13
1905 .. ..	285.00	344.29	1.20
<b>Total .. ..</b>	<b>1,068.00</b>	<b>1,932.13</b>	<b>1.81</b>

ROCK OF AGES, G.M.L. 1338.—Two or three fair sized hematite-bearing quartz lodes run through this lease on a bearing of 186 degrees, dipping at an angle of about 75 degrees to the west; along the hanging wall of the best defined of these, runs a small white quartz reef, on which a fair amount of work has been done down to water level. The reef is somewhat irregular, but it was impossible to see much owing to most of the block having been stoped out and to no development work being done; it is said to have averaged about two feet, but is, however, very small in the north face. The country is very soft, and consists of a decomposed, somewhat schistose greenstone; water was struck at 130 feet, and is said to be fresh and drinkable. The property was idle at the time of my visit.

*Rock of Ages, G.M.L. 1338.*

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	ton.	fine ozs.	ozs.
1902 .. ..	49.00	151.30	3.08
1903 .. ..	293.50	713.49	2.09
1904 .. ..	224.00	299.94	1.33
1905 .. ..	—	—	—
<b>Total .. ..</b>	<b>566.50</b>	<b>1,164.73</b>	<b>2.05</b>

SONS OF WESTRALIA, G.M.L. 934.—This property is situated a little over four miles to the south of Burtville townsite. The workings are on a fair-sized quartz reef, which runs on a bearing a little east of north, and dips at a fairly steep angle to the westward; this reef is said to have been from three to five feet in thickness all through the workings, and to have carried good values right through. It has been worked to a depth of 140 feet (v.d.); from the 100 feet level to the surface, a block from 400 to 500 feet in length has been stoped out, and at 140 feet about 150 feet of driving has been done on the reef, but no stoping. The reef is said to have averaged about four feet along this drive, but owing to the workings being flooded I was unable to make an examination of them. Near the surface in one

the reef is about four feet thick, and has good clean walls, the all being especially good; a little chloropal (a silicate of iron) is associated with the quartz near the surface on this wall, giving it a characteristic green colour, and is also found on the wall itself.

The country is greenstone, very soft and rotten, as far as opened. Water was met with at 100 feet, but is salt.

*Sons of Westralia, G.M.L. 934.*

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	ton.	fine ozs.	ozs.
899 .. .. .	35.00	187.50	5.35
900 .. .. .	90.00	669.70	7.44
901 .. .. .	243.00	665.78	2.74
902 .. .. .	748.00	1,826.39	2.44
903 .. .. .	103.00	422.61	4.10
904 .. .. .	130.00	143.73	1.10
905 .. .. .	—	—	—
Total .. ..	<b>1,349.00</b>	<b>3,915.71</b>	<b>2.90</b>

MIKADO, G.M.L. 943.—The accompanying plans show the extent of work which has been done on this lease. Several lines of reef are being worked, but the majority of the work has been done on that which is known as the Mikado reef. This reef can be traced on the surface in a roughly north-north-easterly and south-south-westerly direction for a distance of about 20 chains, the outcrop at the south end being 8 to 10 feet in thickness, and very continuous; in the workings—which are to the north of the big outcrop—which is apparently no good—it is very irregular, varying in thickness at different distances from a solid body of quartz two to three feet thick, to a string of mere threads, these, in turn, sometimes cutting out entirely, and at other times making again into a fairly solid mass; there are a number of small leaders on both sides of the main reef, these are mostly very small and consist of a series of irregular veins with narrow threads of quartz connecting them; they are as small as a rule, and often only extend for a few feet, and are often much flatter than the main line, and run into it. At the 110 feet level, three lines of reef have been opened up, but insufficient work has been done on two of them to get an accurate idea of their extent or relationship. A little to the north of the main shaft an east and west fault dipping to the south cuts across the reef, which is about six feet to the east and very much broken. This is evidently the continuation of the shear line seen on the surface near the north-east corner of the lease, and marked on the surface by a fair-sized hematite-bearing quartz lode. The workings are only accessible to the 110 feet level, being full of water below. The country is very soft and easy to work and shows no signs of becoming hard even at the 140 feet level; it consists of greenstone, the foliation running slightly east of north, and dipping

steeply west, and it is parallel to these lines of foliation that the reef occurs. A fairly good supply of water was struck at 110 feet, but it is salt; it is, however, being used for boiler purposes with satisfactory results.

*Mikado, G.M.L. 94?*

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
1900 .. .. .	62.00	38.93	.63
1902 .. .. .	145.00	90.45	.62
1903 .. .. .	135.00	76.76	.57
1904 .. .. .	60.00	42.00	.70
1905 .. .. .	622.50	648.79	1.04
Total .. ..	1,624.50	886.93	.86

STATE BATTERY.—A State Battery (*Photograph 8*) has been erected at Burtville, and since starting operations in October, 1903, the mill has crushed, up to the close of 1905, 10,869 tons of ore, yielding 27,907ozs. of gold, or an average of a little over 2½ozs. for every ton crushed.

The following Table, compiled from the official statistics, shows the total gold returns from the leases at Burtville up to the end of 1905:—

Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
Away from Home Lease, G.M.L. 1041T, 1087T	1,417.50	3,520.76	2.48
Banker, G.M.L. 1397T	229.50	349.80	1.52
Baron Clive, G.M.L. 1100T	89.00	126.38	1.42
Black Swan, G.M.L. 940T	1,310.50	1,731.37	1.32
Black Swan Proprietary, G.M.L. 940T			
Bond's Find, G.M.L. 1019T	1,068.00	1,932.13	1.81
Brothers, G.M.L. 1054T	515.50	923.05	1.79
Blue Moon, G.M.L. 1666T	17.00	33.73	1.98
Castlereagh, 1598	25.00	40.06	1.60
Carib, G.M.L. 944T	497.00	460.99	.92
Climax, G.M.L. 1369T	8.00	2.47	.31
Cremorne, G.M.L. 1592T (1494T)	188.00	381.79	2.04
Edinboro' Castle, G.M.L. 271T	210.00	503.61	2.39
Edinboro' Castle, G.M.L. 811T	478.00	911.02	1.91
Edinboro' Castle North, G.M.L. 1012T	136.00	204.88	1.50
Edinboro' Castle South, G.M.L. 809T	31.00	166.10	5.35
Edith Hope, G.M.L. 841T	565.00	301.75	.53
Eldorado, G.M.L. 1112T	47.25	43.42	.91
Eureka, G.M.L. 1423T	14.25	5.18	.36
Exchequer, G.M.L. 1345T	343.00	109.64	.32
Enterprise, G.M.L. 1551T	96.00	36.78	.38
Floater, G.M.L. 1234T	..	* 3.44	..
Fortunatus, G.M.L. 1493T	4.50	2.84	.63
Golden Bell, G.M.L. 1553T	978.50	3,566.18	3.64
Golden Bell North, G.M.L. 1566T	325.25	709.58	2.15
Golden Flat, G.M.L. 1104T	50.65	191.03	3.77
Golden Fleece, G.M.L. 1164T	44.00	30.42	.69
Golden Orbit, G.M.L. 1398T	1,188.50	2,192.75	1.84
Golden Ring, G.M.L. 801T			

\* Specimens.

URVEY.

PHOTO. 8.

*Bulletin 24.*



Gibson.

**State Battery, Burtville.**

Govt. Photo. Litho.







Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
Golden Ring East, G.M.L. 1037t ..	12.75	24.57	1.92
Gabberwock, G.M.L. 1457t ..	13.00	38.47	2.96
Hard Lump, G.M.L. 1411t ..	25.00	28.03	1.12
Independence, G.M.L. 1293t ..	12.00	7.95	.66
Karridale South, G.M.L. 1400t ..	13.00	11.81	.91
Karridale, G.M.L. 1010t ..	1,628.58	4,882.59	2.99
Killarney, G.M.L. 1287t (1062t) ..	46.00	36.04	.79
Lady Kate, G.M.L. 1261t ..	12.00	11.81	.98
Lady Myrtle, G.M.L. 1609t ..	70.00	57.94	.82
Leviathan, G.M.L. 944t, etc. ..	203.75	83.39	.40
Maori Chief, G.M.L. 1048t ..	334.60	1,684.48	5.03
Maori Chief Extended, G.M.L. 1114t ..	118.00	506.49	4.29
Marion, G.M.L. 1647t ..	12.00	4.67	.39
Maxim, G.M.L. 1384t ..	164.90	141.81	.86
Maxim North, G.M.L. 1404t ..	15.05	9.06	.60
Meantime, G.M.L. 1635t ..	7.00	10.49	1.49
Merry Pilgrim, G.M.L. 1314t ..	81.00	86.48	1.07
Mikado, G.M.L. 943t ..	1,024.50	896.93	.86
Moi Ami, G.M.L. 1434t ..	128.00	311.59	2.43
Mount Brown, G.M.L. 1265t ..	31.50	25.70	.81
Mount Weld, G.M.L. 673t ..	67.00	31.08	.46
Mount Weld Consols, G.M.L. 1105t ..	265.50	117.06	.44
Mount Wilga Proprietary, G.M.L. 833t ..	296.00	412.25	1.39
Mystery, G.M.L. 1664t (1563t) ..	154.00	219.21	1.42
Nil Desperandum, G.M.L. 1044t ..	975.00	2,518.24	2.58
Nil Desperandum North, G.M.L. 1286t ..	134.30	348.06	2.59
Nonpareil, G.M.L. 1436t ..	22.00	22.10	1.00
Oldfield, G.M.L. 1292t ..	76.40	156.27	2.04
Ophir, G.M.L. 1217t ..	41.00	24.61	.60
Ophir No. 2, G.M.L. 1389t ..	60.35	42.68	.70
Pluck Up, G.M.L. 1307t ..	13.50	20.39	1.51
Prior Right, G.M.L. 1536t ..	14.00	5.09	.36
Queen of Hearts, G.M.L. 1317t ..	15.00	26.08	1.66
Queen of the North Extended, G.M.L. 478t ..	60.00	139.11	2.32
Red Rover, G.M.L. 1331t ..	30.50	11.62	.38
Riddle, G.M.L. 1057t ..	378.25	852.49	2.25
Rise Again, G.M.L. 1337t ..	8.40	10.90	1.29
Rock of Ages, G.M.L. 1338t ..	566.50	1,164.73	2.05
Roscommon, G.M.L. 1417t ..	577.00	377.80	.65
Sailor Prince, G.M.L. 781t ..	3,891.00	4,408.15	1.13
Sailor Prince No. 1 South, G.M.L. 852t ..	64.00	32.21	.50
Savage Captain, G.M.L. 1089t ..	1,515.20	4,706.03	3.10
Silistrea, G.M.L. 1631t ..	12.00	5.10	.42
Sons of Westralia, G.M.L. 934t ..	1,349.00	3,915.71	2.90
Surprise, G.M.L. 1461t (853t) ..	72.00	203.28	2.82
Tattersalls, G.M.L. 1668t ..	5.00	10.24	2.05
Tempus, G.M.L. 1068t ..	987.50	3,242.40	3.28
Third Attempt, G.M.L. 1169t ..	8.00	7.37	.92
Tired Feeling, G.M.L. 1024t ..	125.00	166.89	1.33
Tower Hill, G.M.L. 1325t ..	8.00	10.62	1.33
Treble Handed, G.M.L. 1634t (1350t) ..	185.00	1,032.55	5.58
True Blue, G.M.L. 1464t ..	83.00	147.41	1.77
Try Again South, G.M.L. 1412t ..	33.00	156.69	4.74
Turn Over, G.M.L. 1466t ..	36.55	17.83	.48
Wanderer, G.M.L. 1011t ..	1,122.65	1,920.19	1.71
Wanderer South, G.M.L. 1413t ..	65.00	69.91	1.07
Waihine, G.M.L. 1116t ..	10.50	11.13	1.06
Wee Macgregor, G.M.L. 1605t ..	18.00	36.28	2.01
Sundry Claims ..	541.65	426.50	.78
At Burtville State Battery ..	17.00	* 896.33	—
Burtville Cyanide Works ..	..	† 1,551.29	..
Burtville Ore Reduction Works ..	..	† 949.53	..
Trig Hill Battery ..	..	..	..
<b>Total .. ..</b>	<b>29,534.28</b>	<b>57,764.18</b>	<b>1.95</b>

\* Includes 888.73 ozs. by cyanide.

† By cyanide.

## Erlistoun District.

The road from Laverton to Duketon for the first twelve miles passes over plains covered with recent deposits and broken here and there by outcrops of low greenstone ridges, and then over a couple of miles of granite similar to that at Mount Crawford, afterwards over loam flats and sand plains to a point about two miles beyond the Cork Tree Hotel, where the granite again outcrops, having been apparently continuous the whole way, beneath the sand plains. This granite occupies the country for about another six miles, when it gives place to greenstones of the usual type, traversed by several very persistent bands of hematite-bearing quartz, and extending on past Mount Varden and on towards Erlistoun and Duketon. This area of granite appears to be different from the main body farther east, and though it is probably part of that to the west of Baneygo, it is similar to that of Crawford, and appears to be newer than and intrusive into the greenstones.

The greenstones of the Mount Varden belt occupy a very considerable area, having a width known to exceed 10 to 12 miles, and extending northerly as far as Duketon; a considerable portion of this area is, however, hidden beneath a great thickness of recent detrital deposits; the mining centres of Mount Varden (King of Creation and Little Doris), Kirkpatrick's, Erlistoun (Mistake), and Baneygo are all situated on this belt, Duketon appearing to be about the north-western limit of it. The eastern boundary of the belt is the large body of granite which lies some four miles east of Mount Varden, and apparently runs continuously from Burtville on northerly past Duketon; the western boundary is not known from actual personal observation, but near the north end it is formed by a belt of granite lying some half dozen miles west of Baneygo, and apparently continuous with that crossing the road between Crawford's Well and Cork Tree.

### Mount Varden.

The district officially known as Mount Varden lies about 36 miles to the north of Laverton; as before stated, the rocks comprising the auriferous area consist of greenstones of the usual type traversed by several very persistent parallel bands of hematite-bearing quartz, and here, having a width of about ten miles, they are mostly of a massive and foliated variety, and are considerably weathered and decomposed. Three main lines of hematite-bearing quartz lodes traverse these greenstones running on a bearing about 15 degrees west of north; these are very persistent and can be traced across country for several miles, usually in the form of low rough ridges and isolated hills, often of considerable height.

The most easterly of these lines is the one of which Mount Varden forms the highest point; this belt is several chains in width.

VEY.

PHOTO 9.

*Bulletin 24.*



SON.

**Quartz Reef, Erlistoun.**

Govt. Photo. Litho.







PHOTO. 10.

*Bulletin 24.*



Quartz Reef, Erlistoun.

Govt. Photo. Litho.







and consists of altered greenstone schist and hematite-bearing quartz, being very similar to the belt at Cock of the North, Laverton; it runs on a bearing of about 243 degrees, dipping steeply to the west, and can be followed both north and south for several miles; several fair sized lenticular reefs are associated with it, and one or two of these are being worked with fairly satisfactory results. The second, or middle line, is about two miles to the west of this one, the highest point on it forming the hill known as Nolan's Trig. (22); it runs on a bearing about 15 degrees west of north, and dips at an angle of about 80 degrees to the west. At Nolan's Trig. it is over a chain in width and consists of almost pure banded blue and white quartz, a little farther both north and south, however, it is of the usual hematite-bearing type; from the top of this hill the belt can be seen extending in the form of low isolated hills for several miles both north and south. The third line lies about a mile to the westward of this, and is similar to it in all respects, but its extent appears to be more limited.

With the exception of the hills formed by these belts the greater part of the country is flat and covered with recent detrital deposits, especially to the west of the middle belt; eastward of this there is a greater extent of rock outcrops, these consisting of massive greenstones traversed by a few small hematite-bearing quartz lodes, and also by several north and south belts of schists within which the normal quartz reefs are usually found.

Eastward of Mount Varden, the country is more hilly, and consists of greenstone hills and ridges capped with ironstone conglomerate (laterite), these extending east for four or five miles till the main granite belt is reached.

The quartz reefs of this district are of two classes:—

- (a.) Lenticular quartz reefs associated with the hematite-bearing quartz lodes; and
- (b.) Quartz reefs of the normal type, occurring entirely in the greenstones. (*Photographs 9 and 10.*)

Class (a) is represented by the Spes Unica, City of Auckland, and King of Creation reefs, and class (b) by the Little Doris and Bungarra.

The principal mines working in this district at the time of my visit were the King of Creation, Spes Unica, Bungarra, and Little Doris.

### The Mines.

**KING OF CREATION, G.M.L. 1382.**—A wide belt of hematite-bearing quartz and altered greenstone schist (the continuation of the Mount Varden belt) runs through this lease, on a bearing slightly west of north; associated with it are veins and lenticular masses of quartz, the latter often of large size; these usually run

a few points more westerly than the schists, and overlap each other slightly, dipping with the schists at a steep angle to the west. These lenses are of white, glassy quartz, generally strongly laminated, and vary considerably in their gold contents, the best stone usually being found in the centre portion of the lens. In addition to these large makes of stone a number of small leaders are associated with the schists, usually running parallel to them; these, though small, are sometimes exceedingly rich.

Several shafts were put down on the property by previous owners, but little or no work was done from any of them, and they have since been abandoned; the deepest of them, which is about 5 feet below water level and still in soft country, is now being used as a water shaft, the water being fresh and drinkable. From this shaft, which is on the west side of the main belt of schists towards the north end, two crosscuts have been put in easterly under the outcrop of a couple of large quartz masses, one at 50 feet and one at water level (110 feet); of these the former is in about 100 feet, the whole length of it being in what is practically one large lode, consisting of highly altered greenstone schist highly impregnated with quartz in veins and gashes; running through and with this lode are five fair-sized quartz reefs, ranging from two to five feet in thickness, and about 10 to 20 feet apart. No work, however, has been done on any of these, though they are all said to carry gold; the bottom crosscut is in 40 feet, the first thirty of which are in practically solid quartz and the remaining ten in schist with seams of quartz; it is not in far enough to cut all the makes of stone met with above. A few tons of stone were crushed from a seam near the centre of this big make of stone, with very satisfactory results, but no further work has been done upon it. At present the only work being done on the property is in a large irregular opencut a little to the north of the water shaft; stone has been taken from this to a depth of about 30 feet, and is now being broken at about 15 to 20 feet from the surface; the reef in this cut averages about 6 feet in thickness, and is pretty low-grade, the best results being obtained as a rule near the centre of the reef. Two bulk crushings from this opencut are said to have averaged 14 dwts. and 18 dwts. respectively.

Towards the south end of the Lease, a small quartz leader running alongside a body of hematite-bearing quartz has been worked to a depth of 30 or 40 feet; this leader was only an inch or two in thickness, and was very short, but some exceptionally rich stone was taken out of it.

There is a large body of low-grade gold-bearing stone on this property, which seems well worthy of more systematic prospecting than has been given to it so far.

*King of Creation, G.M.L. 1382.*

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
.. .. .	34.00	48.44	1.42
.. .. .	109.00	46.78	.43
total .. ..	143.00	95.22	.66

NICA, G.M.L. 1391.—Situating about half-a-mile south of Creation, and on the same line of schist and hematite-quartz lodes, which runs right through the centre of the so-called hematite-bearing quartz lodes, which are alterations of the schists, vary from banded quartzite through blue and white banded quartz to a merely ironstained schist. Associated with these, and dipping with them, are several fair-sized lenticulars, these sometimes being up to four feet in thickness, great length or regularity. The present workings are these reefs on the western side of the main belt of schist, merely of a vertical shaft sunk to a depth of 100 feet. Point drives have been put in 90 feet north and 25 feet the reef, and a little stoping done from the north drive. It is from two to three feet on the surface, but in this drive, irregular and consists of a series of broken lenses, varying in length and apparently pitching to the south; occasional quartz dies out altogether and its place is taken by schist, it carries a little gold; the best stone is where the quartz fills the whole space between the walls of the lode. No work has, however, been done on this reef to give an idea of its exact size or possibilities, but the work has proved quartz lenses are very irregular, and that they do not carry vertically.

In addition to this work, a second shaft has been sunk to a depth on a fair-sized lens of stone in the same line of reef some further north; this shaft was inaccessible, but the lens, some 3 feet wide on the surface, appeared to be cutting

The belt of schists is full of these lenses of quartz, varying from a few inches up to two or three feet in thickness and all carrying gold, but being too short and irregular to be of value. The schists themselves carry a little gold, but not enough to make them payable.

In 1905 this lease crushed 58.00 tons for a yield of 27.18 ozs., an average of .46 ozs. per ton.

BUNGARRA, G.M.L. 1480.—Situating east of the King of Creation. The reef of crushed greenstone, with massive greenstone which is still fairly soft in the lower work variety is very hard and solid. The work vertical shaft down 100 feet; at 30 feet a northerly along the reef for 110 feet, and the surface, and in addition about 25 feet of southerly at this same level; at the 100 feet put in along the reef for 95 feet north and 20 feet stopping done from the north drive just beside which runs on a bearing of 345 degrees, and dipping to as much as 12 inches, and averaging about 6 degrees, is very small and irregular, varying from 1 to 2 inches, and makes of stone are mere bunches and do not any distance, either vertically or horizontally. Some has been obtained from the bottom level, the last cut is said to have given an average of nine to ten ounces of gold.

*Bungarra, G.M.L. 1480.*

Year.	Ore crushed.	Gold therefrom.
1905 .. .. .	tons. 39.00	fine ozs. 292.72

LITTLE DORIS, G.M.L. 771 (*Photograph 11*).—posit in this property is similar to that in the Bungarra of a small irregular quartz reef enclosed in a narrow stone schists some 30 or 40 feet in width and bounded by massive greenstones. (Fig. 4). This belt of small irregular quartz veins, most of which carry fair amounting with the foliation of the schists and dipping with west. The main line of reef being worked is very irregular; at the south end in the old workings it was three feet in thickness, but in the present workings its maximum feet in thickness; the bunches of stone are very irregular, out in a few feet; the bunches of stone are very irregular, carry their size for any great distance either laterally or neither are they all uniform in their gold contents. They have been traced on the surface for some 800 feet on a bearing of 345 degrees, and carries gold for the whole of this length as before stated, the values vary a good deal; the stone good deal of carbonate of copper, this rendering treatment what difficult.

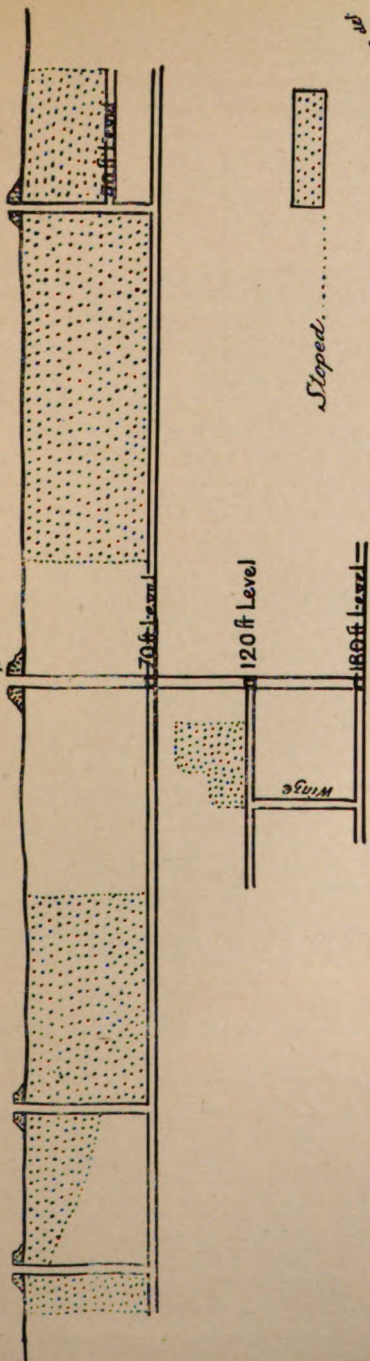
Water level is about 70 feet, the water being salt; it is pumped from the bottom level at the rate of about 15,000 gallons per day.



MAIN SHAFT

N.

S



SECTION SHEWING THE APPROXIMATE AMOUNT OF WORK DONE ON LITTLE DORIS G.M.L. 771. ERLISTOUN MT MARGARET G. F.  
SCALE 100 ft TO 1 INCH.





EY.

PHOTO. 11.

*Bulletin 24.*



on.

**Little Doris Gold Mine, Erlistoun.**

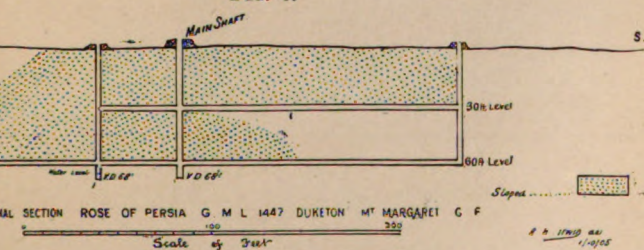
Govt. Photo. Litho.







FIG. 6.





The country in the vicinity of the reef (the schists) in the lower workings is still pretty soft, but the massive greenstones enclosing the schists are very hard and solid. The accompanying sketch section (Fig. 5) shows, from figures supplied by the manager, the approximate amount of work which has been done on this property up to the end of August, 1905.

*Little Doris, G.M.L. 771.*

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	fine ozs.	ozs.
1898	..	..	..	60.00	140.93	2.35
1899	..	..	..	100.00	131.92	1.31
1900	..	..	..	40.00	26.19	.65
1901	..	..	..	88.00	176.52	2.00
1902	..	..	..	16.00	28.70	1.79
1903	..	..	..	160.00	239.94	1.49
1904	..	..	..	235.00	252.75	1.08
1905	..	..	..	150.00	207.72	1.31
Total .. ..				849.00	1,204 67	1.41

**Kirkpatrick's or Little Battery.**

This centre is situated about seven miles north of the King of Creation, on the Duketon road; it is in the same belt of greenstones, but the banded quartz lodes are absent from this particular locality, though they re-appear again farther north at Baneygo and Eristoun. The country consists of greenstone schists foliated about north and south, and within these occur auriferous quartz reefs, running with the schists, and dipping with them to the east. These reefs are lenticular in habit, and mostly small, seldom exceeding a foot in thickness. Several of them have been worked with varying results, the most important being that known as Kirkpatrick's, on which a good deal of work has been done to a depth of 120 feet; this reef averages about a foot in thickness, but is very bunchy, often going from 18 inches to almost nothing in a few feet. A three-head battery is erected on the property and a good amount of gold has been won from it, the returns being as shown below. The water level is about 65 feet, the supply being salt and unuseable. In addition to these small north and south reefs several very large ones are found in this locality; these run in a general east and west direction, and are frequently 20 feet or more in thickness, outcropping for distances of 10 to 20 chains, and often forming razor-backed hills 40 to 50 feet in height; they are of white hungry-looking quartz and apparently carry no appreciable amount of gold.

### Erlistoun.

Erlistoun lies about seven miles north of Kirkpatrick's, on the continuation of the same belt of greenstones. A townsite was laid out here in the early days, but the only sign of it at the present time are the allotment pegs and one small hotel; the two localities where mining operations have been carried out are better known as the Mistake and the Baneygo, taking their names from the principal mines. The Mistake is situated about half-a-mile east, and Baneygo two miles north-west of the surveyed townsite of Erlistoun; this latter locality was, however, practically abandoned at the time of my visit; a large number of leases were taken up here and a lot of work done on them in the past. The country here is greenstone schist traversed by several very persistent belts of hematite-bearing quartz, one of which, about a mile to the west of the Baneygo, can be seen extending across country in a series of low hills north and south for several miles; another belt runs through the leases south of the Baneygo for over a mile, and, in addition, there are several other smaller belts all running pretty well north and south. Quartz reefs are associated with these belts, usually running alongside them, and though small are said in some cases to have yielded very good results.

### The Mines.

**BANEYGO LEASE (G.M.L. 725).**—On this property a good deal of work has been done on a quartz reef running about north and south and dipping fairly steeply to the east. A main shaft has been sunk about 40 feet below water level (90 feet), and a little work done here; above water the reef has been stoped out from the 40 feet level to the surface over a length of 400 feet. These workings had been abandoned for some time past and were inaccessible. The reef is said to have been as much as six feet wide in places, but was very irregular and patchy; the shoot of gold is said to have cut out below the 40 feet level. On the adjoining block to the south the workings were also inaccessible; two parallel reefs have been worked here, and on the eastern one a block 800 feet in length has been taken out down to water level (85 feet). This reef dips west, does not come to the surface, except at the south end, but turns over and dips away easterly, the cap of the turn pitching to the north at a fairly flat angle; this eastern leg does not go down very far, and is not of such good grade as the western leg; the reef was small and very irregular, especially in the lower levels; the second reef lies a couple of chains farther east, and has had a good deal of work done on it; it is exactly similar to the eastern reef in all respects, except that it is somewhat smaller. This reef is partly along the junction of the greenstone schists with an intrusive mass of granite, and partly apparently, in the granite itself, though owing to the irregular nature of the old workings and the rotten nature of the country, it is very hard to get an exact idea of its mode of



hoto., C. G. Gibson.

Govt. Photo. Litho.

**Mistake Gold Mine, Erlistoun.**







occurrence; the body of granite is only of limited extent, as shown by the other workings, but it is, undoubtedly, to the presence of this and other similar bodies that the quartz reefs owe their contorted nature. There is a ten-head battery erected at the Baneygo, and at the time of my visit it was employed in rushing a small parcel from a prospecting show about six miles to the south-east.

*Baneygo Leases, G.M.Ls. 725 (720), 1313.*

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	fine ozs.	ozs.
1898	..	..	..	85.00	149.48	1.75
1899	..	..	..	100.00	258.93	2.59
1900	..	..	..	612.00	839.97	1.37
1901	..	..	..	157.00	180.11	1.14
1902	..	..	..	1,329.00	1,769.78	1.33
1903	..	..	..	—	—	—
1904	..	..	..	200.00	120.41	.60
1905	..	..	..	200.00	129.31	.65
Total	..	..	..	2,663.00	3,447.99	1.23

Between the Baneygo and Mistake Hill (half-a-mile south-east of Eristoun townsite), the country is greenstone schist, mostly flat and free from the occurrence of hematite-bearing quartz lodes; the greater part of it is covered with quartz rubble, resulting from the gradual breaking down of small quartz reefs in the schists; several very large quartz reefs occur here, one in particular about three-quarters of a mile west of Mistake Hill being some 30 feet in width and outcropping for 5 to 8 chains, and rising in one place fully 30 or 40 feet above the surrounding country; this, and most of the other large reefs, runs east and west; it is of white glassy quartz, and its gold contents appear to be *nil*.

Mistake Hill is a low rough ridge formed by a wide belt of banded and, occasionally, hematite-bearing quartz, running on a bearing slightly west of north, and traceable across country for some distance. The Mistake mine is situated on the flat about a quarter of a mile east of this hill; the surrounding country is a greenstone schist foliated in a general north and south direction.

MISTAKE, G.M.L. 1414 (*Photograph 12*). — With the exception of one or two small prospecting shows a few miles to the east, this was the only property on which any work was being done at the time of my visit. A large well-defined quartz reef runs through the lease and the adjoining ones on a bearing slightly east of north, and is easily traceable on the surface for a distance of nearly a mile. The reef is somewhat lenticular in form, being as much as six feet thick in some places and pinching to two in others; at the south end, in the present workings, it is much smaller and a good deal broken; most of the work has been done at this end, that

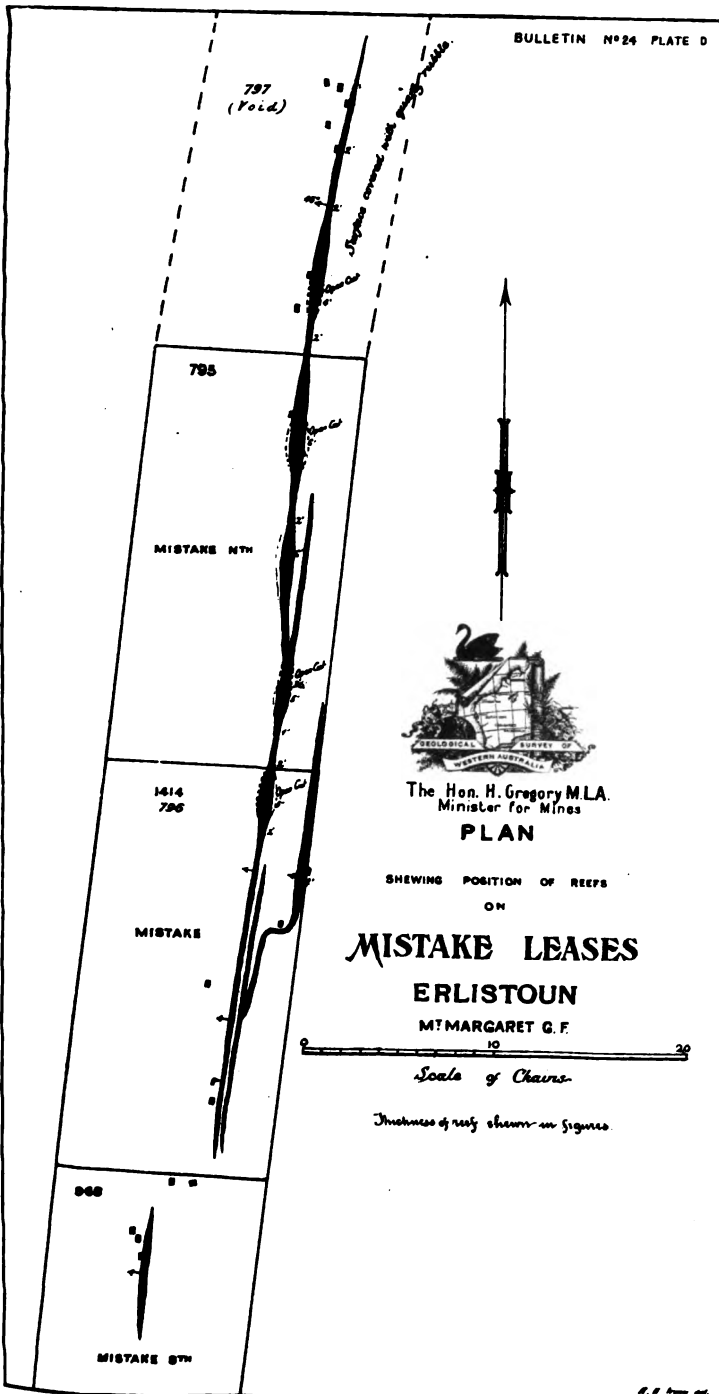
towards the north end consisting merely of a few opencuts, and several shafts sunk to about water level; the largest of these opencuts is some four to five chains in length, and 20 feet in depth, and shows the reef to be of white laminated quartz here about six feet wide, and dipping at an angle of about 45 degrees to the west; farther south the dip is much steeper. On the Mistake lease the reef is split up a good deal, there being three distinct lines here near the surface all uniting into one reef at water level. These reefs are small and irregular, varying from a couple of inches to nearly two feet in places; a considerable amount of work has been done on these reefs at about the middle of the lease, where a main vertical shaft has been sunk to a depth of 150 feet, although most of the work done has been from the 90 feet level to the surface; these workings were flooded, and therefore inaccessible at the time of my visit, and it was impossible to ascertain the extent of them. Work at the present time is being carried on near the south end of the block, where the reef has been opened up to water level (40 feet) for a length of, roughly, 250 feet, and the greater part of this block stoped out to the surface; two lines of reef are exposed in these workings, meeting at water level, and of these the western is the better defined, and it is on this that most of the work has been done. These reefs are bunchy, and vary from a mere thread up to 18 inches, the average thickness being about 6 inches. The bunches are not regular and do not carry their size far, either longitudinally or vertically; along the water level the stone is more regular and continuous, but is still small, averaging from 6 to 8 inches. These south workings are apparently right on the end of the reef, as in a couple of prospecting shafts sunk two chains farther south no sign of it was found. The country is a greenstone schist, very soft and rotten down to water level, and said to be still soft and easy to work at the bottom of the main shaft (150 feet). Water level is about 40 feet, there being an abundant supply, but it is salt.

The accompanying plan (Plate D.) shows the positions and size of the main lines of reef.

The mine is equipped with a ten-head battery.

*Table showing the Yield of the Mistake Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.	
					Ore crushed.	Gold therefrom.
		tons.	fine ozs.	ozs.	tons.	fine ozs.
1899	Mistake, G.M.L. 1414 (796) ...	220-00	151-19	69		
1900	Do. do. ...	566-00	313-94	52		
1901	Do. do. ...	96-00	52-44	53		
1904	Do. do. ...	361-00	163-67	45		
1905	Do. do. ...	273-00	404-26	1-48		
					1,546-00	1,083-60
1899	Mistake North, G.M.L. 795 ...	298-00	233-02	76		
1900	Do. do. ...	300-00	156-54	52		
					598-00	379-56
1900	Mistake South, G.M.L. 968 ...	73-00	243-99	3-38		
1901	Do. do. ...	33-00	202-13	6-12		
					106-00	446-12
	Total ...	...	...	...	2,244-00	1,909-28





WESTRALIA TASMANIA. (Dwyer and Party).—This is a lease recently pegged out some three and a-half miles from the Mistake, and on which, at the time of my visit, prospecting work was being rigorously carried out on a large white quartz reef running north and south through a belt of much altered greenstone schist. A vertical shaft is being put down on this reef and is down to a depth of about 100 feet, but so far no opening out has been done from it; the reef as exposed in this shaft is vertical, and about six feet in thickness, widening out near the bottom to nine feet; it can be traced on the surface for nearly five chains north of this shaft, but is cut off (on the surface) a short distance to the south; about five chains away in this direction is a large white quartz "blow" which is probably a continuation of the reef.

In sinking the shaft, from two to three feet of stone were taken from the west side of the reef, and this gave at the Baneygo battery, an average return over the plates of 15 dwts.

About three chains west of this reef is a second fair-sized parallel quartz outcrop, but no work has been done on it, and again a few chains to the east is a well-defined but smallish reef running north and south alongside a hematite-bearing quartz lode, and dipping at an angle of 60 degrees to the east; this reef can be traced on the surface for about ten chains, and appears to average from one to two feet; it has been opened up in two places to a depth of from 20 to 30 feet, and in each of these is about 18 inches in width; no work beyond this has been done on it, neither has any stone been crushed. The country is greenstone schist foliated north and south, and traversed by numerous small but persistent hematite-bearing quartz lodes, these being more numerous on the adjoining block on the south; in the bottom of the shaft these schists are still very soft and easily worked, and, so far, there is no sign of water, this being because the property is situated on high ground.

Since visiting this locality I hear that the owners have abandoned this lease; this seems rather a pity, as the reef struck me as being one which was well worth further prospecting, especially as the bulk crushing from the shaft gave such satisfactory results.

On the block adjoining this on the south (Cox's) are a number of short lenticular quartz reefs running alongside the hematite-bearing lodes ("ironstone bars"), and a little work has been done on a couple of these. One lens two to three feet wide at the surface was worked for a length of about 30 feet and to a depth of about 20 feet, at which point it cut out on the side of the "bar," which was then followed down for another 50 feet, but without meeting with the reef again. A second lens a little farther south on the same bar was then opened, up; there is here two to three feet of stone but so far very little work has been done on it. The "ironstone bars" on this lease are fairly numerous, but they are considerably faulted and contorted, and the quartz lenses are, as a rule, very irregular and of no length, and, though a few small parcels of stone may be taken out of them, they are not likely to prove of any permanency.

## Duketon.

*(With a Map showing the position of the Auriferous Reefs. Plate V.)*

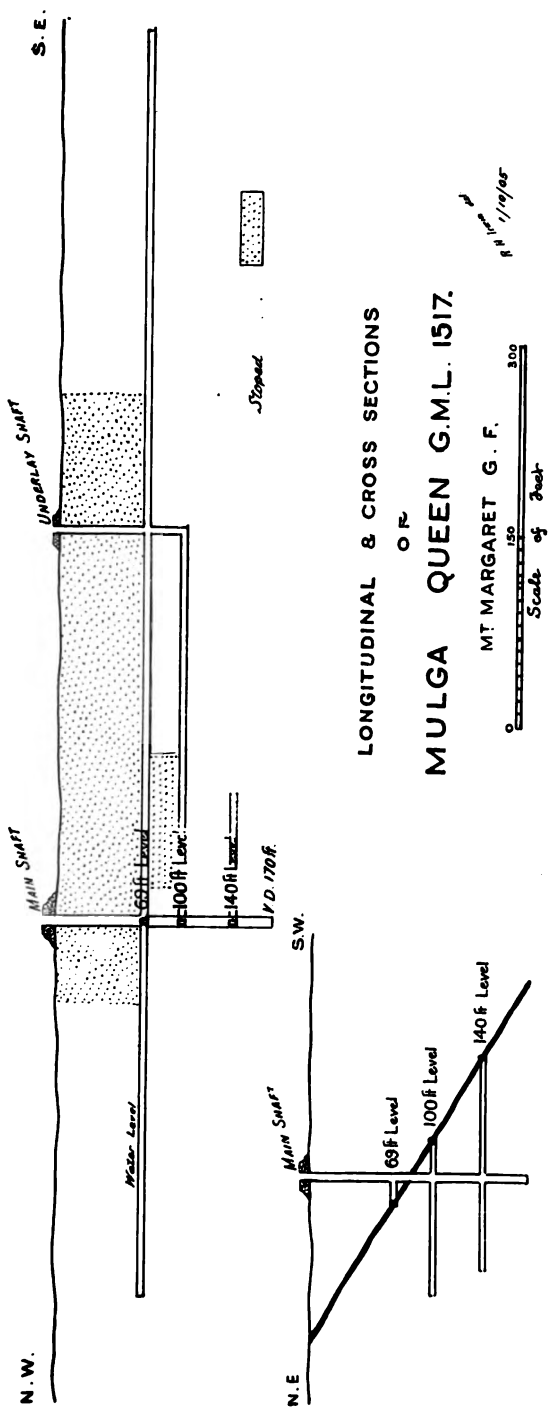
From Erlistoun to Duketon the road passes for the whole distance over country which is almost, without exception, dead level, and covered with a considerable thickness of recent deposits, and pretty thickly timbered with mulga, often of fair size. Owing to the thickness of these deposits, it is impossible to determine what the staple formation is, but it appears to be greenstone, though about six miles from Duketon there is a small outcrop of schists apparently similar to the granitic schists occurring at that place.

At Duketon the country is all dead level, and mostly devoid of rock outcrops except at Pinjie Eda Hill, about two miles south of the townsite, where there is a low ridge of hills trending southerly for a mile or so, and consisting of a fairly soft and weathered granitic schist, the lines of foliation of which strike about north-north-west and dip to the west.

This is the only rock outcrop of any importance in the neighbourhood, and the country in the vicinity of the workings is so decomposed and rotten that it is very difficult to form a definite opinion as to what it really is, but it seems to me that the main line of reefs is situated along the junction of granitic and greenstone schists, being sometimes in the former and sometimes in the latter. The country west from here, and out towards Mulga Queen, consists of granitic schists, while to the eastwards are the greenstones extending for about six miles, when they give place to sand-plains which overlie the main eastern granite belt and extend inland for at least fifty or sixty miles. The junction of these two formations (the granitic and greenstone schists) runs on a bearing slightly west of north and east of south, and, though it is hidden beneath the covering of recent deposits, is approximately indicated by a series of very regular quartz reefs and by the workings on these reefs; these reefs have been followed for a distance of about five miles in a broken line, the greatest length of actual outcrop followed being from three quarters to one mile at the north end, and the greatest break in the line being about a mile; further systematic prospecting would probably reveal other reefs along this line, as they are almost entirely hidden beneath the surface covering and are undoubtedly more nearly continuous than shown by present developments. Most of the principal mines are situated along this line of reef, but there are other reefs in the schists, mostly small, and the greater part of the country is covered with quartz rubble, resulting from the gradual breaking down of quartz reefs and leaders.

At the time of my visit very little work was being done in this district, and most of the properties had been abandoned, principally owing to the fact that they were all low-grade and would not pay to work below water level, this, in some parts of the district being not

FIG. 7.







more than 12 feet below the surface ; the only properties in fact that were actually carrying on active mining operations at Duketon, were the Golden Spinifex (Lauriston), Rose of Persia, and the Wallaroo ; others on which a good deal of work has been done in the past but which are now abandoned, are the Monowai, Water Melon, and Morialta ; all these are on reefs following along the main junction of the granitic schists and the greenstones. One or two other properties have also been worked a few miles to the westward but these had all been abandoned for some time, and the workings were inaccessible.

### The Mines.

**MONOWAI, G.M.L. 810.**—This lease is situated at the extreme south end of the main line and is said to have been one of the first leases worked in the district, it was originally equipped with a ten-head battery, and a lot of work was done on it, but it is abandoned at the present time.

The reef has been proved through this lease and the adjoining ones to the north for a length of over half-a-mile, and what are possible continuations of it have been picked up for another half-mile ; it runs on a bearing slightly west of north and dips at a steep angle to the westward ; as exposed in a small opencut it is about two feet in thickness, and this appears to have been about its average size. The country in which the reef is found is a very decomposed and altered greenstone schist, but the granitic schists appear to come in a couple of chains farther west, while about half-a-mile north from here they are found forming the walls of what is probably the continuation of this same reef. The water level on this south block is 65 feet, but it gradually becomes shallower, proceeding northward.

**ROSE OF PERSIA, G.M.L. 1447.**—In this lease the reef appears to be following right along the junction of the granitic schists with the greenstones, but no crosscutting has been done, and the country in close proximity to the reef is so rotten and altered that it is very hard to say what some of it is ; the reef is rather bunchy, reaching a thickness of nearly six feet in one or two places, the average right through the workings being, however, about two feet ; these big makes of stone are, as a rule, poorer than the smaller portions of the reef. The length of reef, or rather reefs, as there are two at the north end a few feet apart, proved on the surface in this and the adjoining leases is about thirty chains and, as can be seen by reference to the accompanying plan (Plate V.), it runs a little west of north and is in direct line with the Monowai and Golden Spinifex reefs ; its dip is here about 75 to 80 degrees to the east. The accompanying sketch (Fig. 6) shows roughly the extent of the principal workings on the lease, and in addition to this there has been a little work done from a shaft about five chains farther north. The stone in the main workings

is not uniform in value and the shoots are not regular, but they all have a decided pitch to the south. Water level is about 63 feet, and the supply is fresh and drinkable, this being the case all through the district.

*Rose of Persia, G.M.L. 1447.*

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	fine ozs.	ozs.
1903	..	..	..	133.00	198.68	1.49
1904	..	..	..	197.00	263.62	1.34
1905	..	..	..	106.50	81.15	.76
Total	..	..	..	436.50	543.45	1.24

**GOLDEN SPINIFEX AND LAURISTON, G.M.Ls. 1046, 1049.** (*Photographs 13 and 14*).—These leases, which were originally worked as separate properties, are now amalgamated, and all work is being done on the Lauriston lease. A main vertical shaft has been sunk on this lease to a depth of 140 feet, and at the present time driving is being carried on along the reef at the 120 feet level; a good deal of work has been done above this, but the bottom level was the only one from which any work was being done at the time of my visit; the reef, as exposed along this drive, averages about 18 inches in width, being somewhat bunchy; in one place at the north end of the drive it is about five feet, but its values here are no good. Two other parallel makes of stone were cut in the crosscut from the shaft a few feet from the main line, these, however, were no good where cut, and no further work has been done upon them; the values of the main reef were not very good in the bottom level, the best being obtained at the south end, where it is expected that the Spinifex shoot will shortly be met with. Throughout the old workings the average size of the reef was about two feet, some bunches up to eight and nine feet being met with in the Spinifex lease; these, however, were as a rule, not much good, the best values being obtained in the smaller parts of the reef; the quartz is clean and white, and in places is strongly laminated. Down to the 30 feet level the reef dips to the east, but below this it takes a turn, and in the bottom workings is, if anything, dipping to the west; it nowhere comes to the surface on these leases, being covered by a deposit of surface "cement," varying in thickness from 10 to 15 feet; the general trend of it, like all the others on this line, is about north-north-west.

On the Spinifex lease a lot of work has been done, and a block about 500 feet in length has been taken out from the 60 feet level to the surface, in addition to which two vertical shafts were sunk to depths of 95 and 145 feet respectively, both of which were lost in the soft "running" ground met with below water; all these work

GEOLOGICAL SURVEY.

PHOTO. 13.

*Bulletin 24.*



Photo., C. G. Gibson.

Govt. Photo. Litho.

**Lauriston Gold Mine, Duketon.**







Photo., C. G. Gibson.

Govt. Photo. Litho.

**Golden Spinnifex Battery, Duketon.**







gs were inaccessible. The reef in these leases is in granitic schists and runs parallel to their foliation, which is, however, not very strongly marked; these schists are very soft and rotten, especially and a little below water level; and in some places below water owing to the large development of kaolin the country "runs" very considerably, and this, as above stated, has caused the loss of two main shafts on the Spinifex lease, and also necessitates the use of heavy timbering in the workings. The natural water level is about 10 feet, the supply being fresh and suitable for domestic purposes; at the present time it is being pumped from the 120 feet level on the Lauriston at the rate of 5,000 gallons per 24 hours.

*Table showing the yield of the Golden Spinifex Reef.*

Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.		Average rate per ton.
				Ore crushed.	Gold therefrom.	
	tons.	fine ozs.	ozs.	tons.	fine ozs.	ozs.
Golden Spinifex, G.M.L. 1046 ...	110'00	200'40	1'83			
Do. do. ...	776'00	494'79	'83			
Do. do. ...	1,405'00	785'73	'55			
Do. do. ...	324'00	246'04	'72			
				2,615'00	1,726'87	'66
Lauriston, G.M.L. 1049 ...	75'00	61'45	0'81			
Do. do. ...	225'00	434'07	1'93			
Do. do. ...	273'00	337'10	1'20			
Do. do. ...	22'00	22'91	1'04			
				594'00	845'53	1'43
Total ...	...	...	...	3,209'00	2,572'40	'80

WALLAROO, G.M.L. 1455.—This property is situated about a mile and a-half north-north-west of the Lauriston, and is apparently also on or close to the junction of the granitic schists with the greenstones, though in this case the reef itself is well within the greenstones; it has been opened up to a depth of 65 feet, and a block about 40 feet in length has been taken out between this level and the surface, or rather, between this and the bottom of the "cement" which covers the country round here to a depth of about 12 feet. Over this block the reef is said to have averaged about two feet; in the south face of the bottom drive it is nearly six feet and of pretty fair grade, while in the north face it is about two feet; the quartz is clean and white, and in places shows considerable lamination; it is crossed every few feet by a series of joints or "floors" which cut off the gold contents, the usual habit being, it is said, alternate makes of good and poor stone, these being defined by the above-mentioned floors. In the bottom level a good deal of sulphide is coming into the stone and in a short winze sunk from this level it is said to be pretty heavy.

The country is a very soft, rotten greenstone schist foliated parallel to the strike of the reef, which is between north-west and north; water is very abundant and comes in principally along the walls of the reef; its original level was from 13 to 14 feet.

*Wallaroo, G.M.L. 1455.*

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
1904 .. ..	77.00	155.93	2.02
1905 .. ..	485.00	213.24	.44
Total .. ..	562.00	369.17	.65

MORIALTA AND WATER MELON, G.M.Ls. 1236, 1451. — The leases are situated at the extreme north end of the line, and a great deal of work has been done upon them in the past, though they both at present abandoned. The reef is traceable on these and adjoining blocks for a distance of about half-a-mile; at its south end it is in greenstone schists and at its north in granitic schists; at its north end there are two well-defined parallel reefs about two chains apart, both apparently in the granitic schists. The main line of reef appears to have had an average thickness of about three feet, though in some places all those on this line, it is somewhat bumpy, being in some places as much as six feet, and in others again down to not more than two feet. None of the workings were accessible owing to their being flooded, the water level being only about twelve feet below the surface; this fact naturally greatly handicaps the prospector at this end of the field, more especially as there is frequently as much as ten or twelve feet of "cement" overlying the cap of the reef, which is thus placed right at or close to water level, and pumping has to be resorted to before any stone at all can be taken out. The water is fresh and suitable for domestic purposes.

*Table showing the Yield of the Morialta Reef.*

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total.	
					Ore crushed.	Gold therefrom.
		tons.	fine ozs.	ozs.	tons.	fine ozs.
1903	Morialta, G.M.L. 1236 ... ..	300.00	275.95	.92		
1904	Do. do. ... ..	163.00	228.00	1.40		
					463.00	
1903	Water Melon, G.M.L. 1451... ..	105.00	71.68	.68		
1904	Do. do. ... ..	74.00	63.91	.86		
					179.00	
	Total ... ..				642.00	



BULLETIN N° 24 PLATE V

The Hon. H. Gregory M. L. A.

## MAP



## Mulga Queen.

(With a plan showing the position of the Mulga Queen Reefs,  
Plan E.)

From Duketon to Mulga Queen the country is practically all dead level and covered with a varying thickness of recent deposits, the only rock outcrops of any extent being at Inji Jingi Hill and at Mount Maiden; both these outcrops are very much weathered and altered, but at both places the rock appears to be a granitic schist. Mount Maiden is a large flat-topped hill 80 to 100 feet in height and half-a-mile or so in length, trending about north-west, and formed of very much weathered granitic schists capped by a few feet of hard compact quartzite and quartz conglomerate, this latter being only of limited extent; both these (the quartzite and conglomerate) are undoubtedly formed *in situ*, the former being merely a local concentration of silica from the decomposition of the underlying schists, and the latter a cementing together of the quartz rubble with which the hill and the greater part of the country are thickly covered, the cementing material being the fine-grained quartzite. This quartz rubble undoubtedly owes its origin to the gradual breaking down and weathering of small quartz reefs in the schists, both may be described as residual deposits.

At Mulga Queen the country is a greenstone schist, the junction of this with the granitic schists being apparently between Mount Maiden and the townsite and in the near neighbourhood of the Famous Blue mine. Everywhere the rocks are very rotten and decomposed as far as opened up, and as the granitic schists are mostly fine-grained, it is very difficult to discriminate between the two classes owing to the amount of alteration and kaolinisation which has gone on in each of them.

Quartz reefs occur in both classes of rock, and are, as a rule, of fair size, but somewhat irregular and lenticular, this being a characteristic of nearly all the reefs in the Erlistoun district. Taking the district all through the reefs are essentially low-grade, and when the stone has to be carted six or ten miles to the battery there is not much profit left in it for the prospector.

The water level varies from 40 to 70 feet, the supply being invariably fresh and suitable for domestic purposes.

Good timber is fairly abundant, mulga of good size being obtainable anywhere, while white gum of good quality can be obtained from Erlistoun Creek, six to eight miles distant.

This centre is of comparatively recent discovery, and mining operations and business matters generally were pretty brisk at the time of my visit. The principal mine is the Mulga Queen, from which the town takes its name; this property is equipped with a ten-head mill, rock breakers, cyanide plant, and all accessories, and was the first mine in the district to erect machinery.

## The Mines.

The following is a brief description of such of the mines as were working at the time of my visit:—

**MULGA QUEEN, G.M.L. 1517.** (*Photograph 15*).—Situated from half to three quarters of a mile west-north-west of the township. A good deal of work has been done here, as can be seen from the accompanying sketch section of the main workings. The reef, which has been proved through this and the adjoining north block (Plate E), for a distance of over half-a-mile, runs on a bearing of 325 degrees, and at the main shaft dips at an angle of about 30 degrees to the south-west (Fig. 7); both to the north and south of this its dip is considerably steeper; taking it right through, it is pretty regular in size, averaging about two feet; it is somewhat lenticular, but this is not so marked as in some of the reefs in this district, the biggest bunch being only about four feet, while it seldom goes below one foot; in one or two places towards the south end it is a little broken, where it appears to have gone through a harder belt of country, but this is only for a few feet. The stone carries a fair amount of sulphide at the north end close to the surface, but throughout the main workings there is little or none, though the stone is a good deal ironstained, and there are numerous vughs from which the sulphide has been leached out, these often showing fine gold on the walls. As a rule the gold is well in the stone and very fine, and the values of the reef so far have been fairly uniform right along its entire length. The country rock is a foliated coarse-grained greenstone with a little schist along the walls of the reef; it is very soft and rotten even in the bottom workings.

Water level is 69 feet, and the supply is fairly plentiful; it is fresh and makes good boiler and cyanide water.

### *Mulga Queen, G.M.Ls. 1517, 1550.*

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	fine ozs.	ozs.
1904	..	..	..	2,910.00	2,560.48	.88
1905	..	..	..	2,117.00	1,811.86	.85
Total	..	..	..	5,027.00	4,372.34	.86

**MULGA QUEEN No. 1 SOUTH, G.M.L. 1522.**—The main workings on this property are situated on what is possibly the south-easterly continuation of the Mulga Queen reef, though there appears to be a considerable break in it in the intervening lease. Here (Mulga Queen No. 1 South) the reef is somewhat more irregular and lenticular, and, on the average, is slightly smaller, being only about eighteen inches; as far as it was possible to see in the old



by, C. G. Gibson.

Govt. Photo. Litho.

**Mulga Queen Gold Mine, Mulga Queen.**









oto., C. G. Gibson.

Govt. Photo. Litho.

**Famous Blue Gold Mine, Mulga Queen.**





workings it seems to consist of a series of long lenses of various depths, the beginning of each lens lying on the hanging wall of the "tail" of the one above it, as shown in the accompanying diagram (Fig. 8); this lenticular habit appears to be only vertical and not longitudinal; the quartz is white and glassy, and, so far, free from sulphides. The general strike of the reef is 320 degrees, and its dip about 45 degrees to the south-west; it has been proved for a length of about fifteen chains, and may continue northerly for some distance farther; at the south end it appears to have cut out completely.

A good deal of work has been done on the lease, and several shafts have been put down to water level (40 feet) and the reef opened up for a length of about 450 feet at this level, and the greater part of this block stoped out to the surface. At the present time the owners are putting down a main vertical shaft, and have started to crosscut to cut the reef at 100 feet.

The country here is very soft and rotten, and consists of a fine-grained much kaolinised greenstone (?), which is difficult to work in below water owing to its running nature, and necessitates heavy timbering.

The greater part of the eastern portion of this lease is covered to a depth of twelve to fourteen feet with a fine-grained quartzite similar to that forming the capping of Mount Maiden; this probably is overlying an area of granitic rocks; the remainder of the lease, and, in fact, the whole of the country round about, is covered with the ordinary surface "cement" to a depth of ten to fifteen feet.

*Mulga Queen No. 1 South, G.M.L. 1522.*

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
1905 .. .. .	472.50	351.31	.74

FAMOUS BLUE, G.M.L. 1509 (*Photograph 16*).—Several lines of reef run through this property (Plate F.), but only one of them is being worked, this being a large well-defined quartz reef running about north-north-west, and dipping at a fairly flat angle to the eastward. As seen on the workings this reef has an average thickness of about four feet, but is somewhat irregular, varying from a minimum of 18 inches to a maximum of from 6 to 7 feet; it consists of a series of overlapping lenses coming in in the hanging wall, and having an average length of about 100 feet and pitching at a very flat angle to the south. The quartz is white and glassy, and the gold in it is very fine, occurring principally in vughs left by the oxidisation and leaching out of pyrites. The average size of the reef

along the bottom level and the amount of work done on it can be seen from the accompanying diagrams (Fig. 9). This reef is in a foliated and highly decomposed greenstone, apparently close to its junction with what appears to be a belt of granitic schists extending easterly. Several other quartz outcrops occur in these schists a few chains east of the main line; some of these are of considerable size but no length; they run slightly more westerly than the main line. and one near the main shaft runs almost due east and west; these large outcrops appear to be merely surface makes, as a vertical shaft has been put down near the largest of them and a crosscut put in under it without cutting anything. Near the eastern boundary of the lease is a better defined reef running approximately parallel to the main shaft; it is, however, comparatively small, and no work of any description has been done upon it.

In the main reef some very rich stone was taken out from a large open cut; this shoot however has apparently cut out; the stone in the bottom level is somewhat patchy, some being very good and some the reverse; the shoots are small and not regular.

Water was struck at 78 feet (v.d.), and is fresh.

On the adjoining block on the north a little work has been done on the same reef, which here averages about four feet in thickness and has the same properties as in the main workings. It probably extends a good deal farther northwards, but is hidden beneath the recent deposits.

This property is equipped with a Huntingdon mill and rock breakers.

*Famous Blue, G.M.L. 1509.*

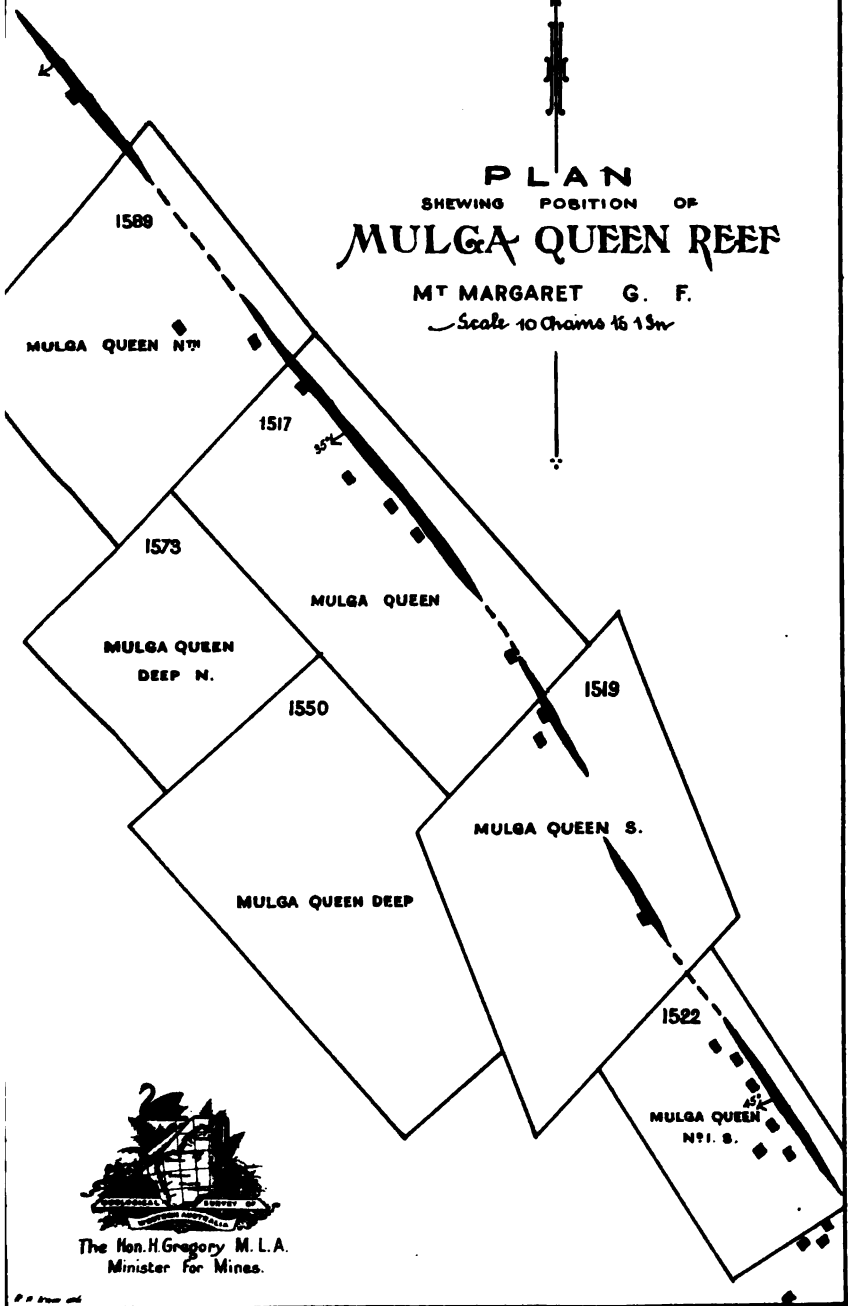
Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	fine ozs.	ozs.
1904	..	..	..	55.00	66.10	1.20
1905	..	..	..	2,357.10	1,303.06	.55
Total	..	..		2,412.10	1,369.16	.57

FAMOUS, G.M.L. 1508.—A large irregular quartz reef runs through this property on a bearing slightly west of north, dipping at an angle of about 30 degrees to the west, and appears to be along or close to the junction of the greenstones with the granitic schists. Very little work has been done on it, and not much can be seen on the surface owing to the covering of recent deposits. The old workings are down to about forty feet, and the reef has been worked out in an irregular way down to this level for a length of about fifty feet; very little could be seen, but in the faces the average of the

PLAN  
SHEWING POSITION OF  
**MULGA QUEEN REEF**

MT MARGARET G. F.

Scale 10 Chains to 1 In

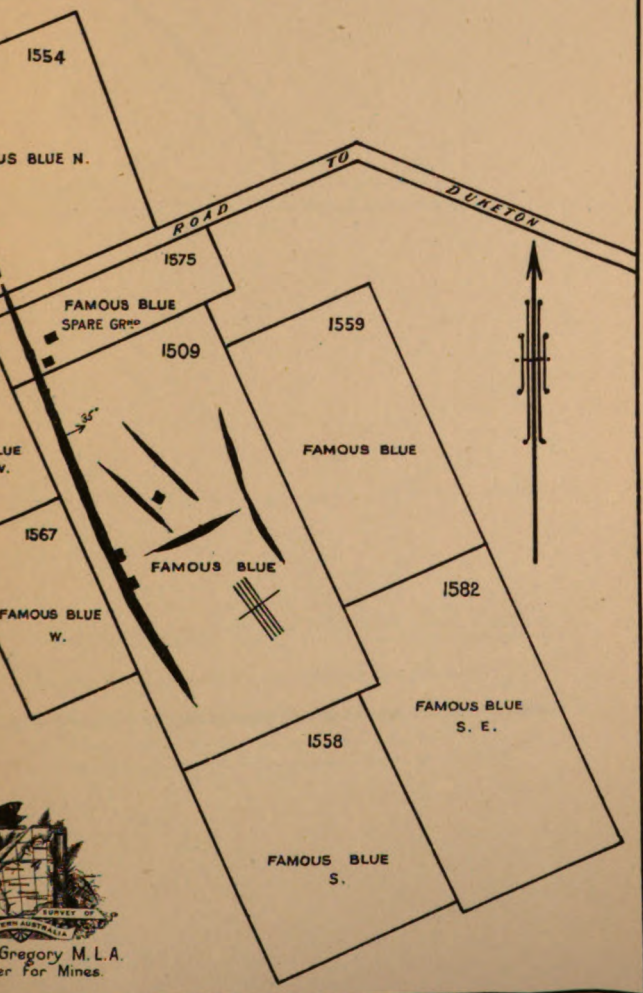


The Hon. H. Gregory M. L. A.  
Minister for Mines.





PLAN  
 SHEWING PORTION OF  
**THE FAMOUS BLUE REEFS**  
 MT MARGARET G. F.  
*Scale 10 Chains to 1 in*

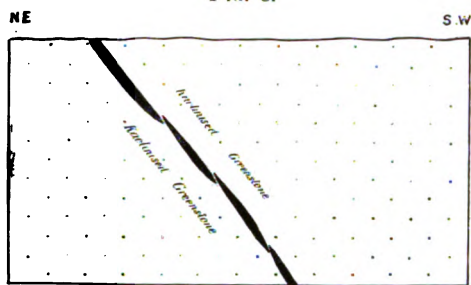


H. J. Pether, Government Lithographer, Perth. W. A.



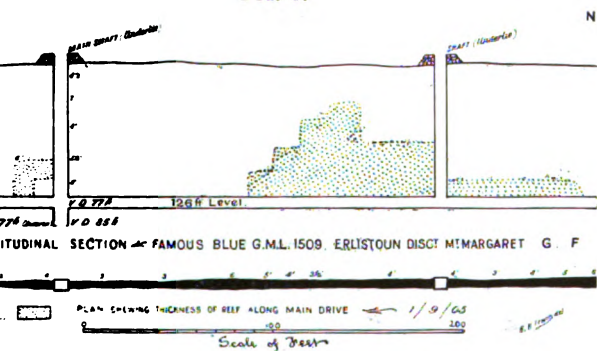


FIG. 8.



CROSS SECTION - SHOWING MODE OF OCCURRENCE OF REEF ON MULGA QUEEN N15°W L152  
M<sup>t</sup> MARGARET G. F.

FIG. 9.



LONGITUDINAL SECTION - FAMOUS BLUE G.M.L. 1509, ERLISTOUN DISC<sup>t</sup> M<sup>t</sup> MARGARET G. F.





reef was about three feet, the stone being white and glassy, some of it showing coarse gold; some pockets of very rich stone were taken out of these workings, and the whole of it is said to be of pretty fair grade; only picked stone was crushed however.

The present owners are at present sinking a new main shaft and are crosscutting at the 100 feet level to meet the reef, and if developments are then satisfactory it is their intention to erect machinery.

*Famous, G.M.L. 1508.*

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	fine ozs.	ozs.
1904	..	..	..	20.00	54.95	2.75
1905	..	..	..	89.00	231.68	2.60
Total	..	..		109.00	286.63	2.63

About half-a-mile east of the Famous, a small party of men are engaged in dryblowing, this being the only alluvial patch worked in the district, with the exception of Frost and Baker's patch eight miles south-east; there is only a very small area of pay dirt, and very little gold is being got, the biggest piece so far being about 14 dwts. There is from 6 to 10 inches of dirt before reaching bottom; the gold appears to be shed from small quartz leaders which run through the country in all directions, and probably occurs principally at the points of intersection of these. The whole locality is covered with quartz rubble resulting from the gradual breaking down of similar and larger quartz reefs, and there seems no reason why other and larger alluvial patches should not be found in this locality.

There are several other shows in addition to those mentioned working in the district, principally in the neighbourhood of Erlistoun Creek, some of which are said to be looking very well, and altogether at the time of my visit the place seemed very flourishing, which is more than could be said of the rest of the Erlistoun district.

The following Table, compiled from the official statistics, shows the total gold Returns from the leases in the Eristoun district. up to the end of 1905:—

Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	ozs.
A1, G.M.L. 1521r .. .. .	46.00	54.48	1.18
Baneygo Leases, G.M.Ls. 725r (720r), 1313r	2,683.00	3,447.99	1.28
Battler, G.M.L. 1591r .. .. .	35.00	35.92	1.02
Battlers, G.M.L. 1409r .. .. .	212.00	454.06	2.14
Ballantraye, G.M.L. 1599r .. .. .	44.00	30.36	.69
Bungarra, G.M.L. 1480r .. .. .	39.00	292.72	7.51
Caledonia Leases, G.M.Ls. 1300r, 1322r ..	1,000.00	1,559.07	1.56
City of Auckland, G.M.L. 1450r .. .. .	43.00	139.95	3.25
Commonwealth, G.M.L. 1627r .. .. .	83.00	24.50	.29
Connemarra, G.M.L. 1552r .. .. .	96.50	29.91	.31
Crescent, G.M.L. 754r .. .. .	4.00	*66.03	—
Easter Gift, G.M.L. 961r .. .. .	50.00	35.27	.70
Eristoun Proprietary, G.M.L. 543r .. .. .	80.00	84.50	1.56
Eristoun Proprietary G.M. Co., G.M.Ls. 795r (796r, 1185r) .. .. .	1,138.00	641.36	.56
Eristoun Queen, G.M.L. 1583r .. .. .	4.50	11.55	2.56
Ethel, G.M.L. 1568r .. .. .	23.00	31.87	1.38
Eureka Reward, G.M.L. 1594r .. .. .	31.00	9.70	.31
Famous, G.M.L. .. .. .	109.00	286.63	2.63
Famous Blue, G.M.L. 1509 .. .. .	2,412.10	1,369.16	.57
Germania, G.M.L. 1660r .. .. .	102.50	83.90	.81
Gladys, G.M.L. 1539r (762r) .. .. .	42.25	72.04	1.70
Golden Boulder, G.M.L. 732r .. .. .	23.00	55.94	2.93
Golden Spinifex, G.M.L. 1046r .. .. .	2,615.00	1,726.87	.66
Golden Star, G.M.L. 1533r .. .. .	20.00	8.57	.42
Idaho, G.M.L. 726r .. .. .	97.00	121.73	2.25
King of Creation, G.M.L. 1382r .. .. .	143.00	95.22	.66
King of Eristoun, G.M.L. 797r .. .. .	104.00	78.60	.75
Lauriston, G.M.L. 1049r .. .. .	594.00	845.53	1.42
Lady Bella, G.M.L. 1460r .. .. .	55.00	41.38	.75
Lady Ethel, G.M.L. 1355r .. .. .	53.00	57.25	1.08
Little Dorris, G.M.L. 771r .. .. .	849.00	1,204.67	1.41
Marmont, G.M.L. 1491r .. .. .	60.50	17.62	.29
Mount Maiden Reward, G.M.L. 1432r ..	376.50	171.65	.45
Mistake, G.M.L. 1414r .. .. .	1,546.00	1,083.60	.70
Mistake North, G.M.L. 795r .. .. .	593.00	379.56	.64
Mistake South, G.M.L. 968r .. .. .	105.00	446.12	4.25
Morialta, G.M.L. 1236r .. .. .	463.00	503.95	1.08
Mulga Queen, G.M.Ls. 1517r, 1550r ..	5,027.00	4,372.34	.86
Mulga Queen No. 1 South, G.M.L. 1522r	472.50	351.31	.74
O'Connor's Reward, G.M.L. 1510r .. ..	39.50	45.28	1.14
Parramatta, G.M.L. 1684r .. .. .	35.00	38.66	1.10
Perseverance, G.M.L. 1593r .. .. .	116.50	71.19	.61
Reccaboni, G.M.L. 1643r .. .. .	24.00	43.33	1.80
Rosa Kathleen, G.M.L. 1241r .. .. .	87.00	80.29	.92
Rose of Persia, G.M.L. 1447r .. .. .	436.50	543.45	1.24
Rose of Persia No. 1 South, G.M.L. 1516r	18.00	15.50	.86
Ruby, G.M.L. 1611r .. .. .	97.50	55.18	.56
Salt Bush Reward, R.C. 5r .. .. .	..	† 22.95	—
Spes Unica, G.M.L. 1391r .. .. .	58.00	27.18	.46
Sweet Nell, G.M.L. 1537r .. .. .	51.50	† 161.08	—
Sydney Mint, G.M.L. 144r .. .. .	31.00	59.84	1.93
Two Jims, G.M.L. 976r .. .. .	8.00	22.82	2.85
Wallaroo, G.M.L. 1455r .. .. .	562.00	369.17	.65
Watermelon, G.M.L. 1451 .. .. .	179.00	135.59	.75
Sundry Claims .. .. .	451.90	448.09	.99
Duketon State Battery .. .. .	..	‡ 24.60	—
District generally .. .. .	..	† 1,099.43	—
Total .. .. .	23,660.75	22,485.08	.95

\* Includes 45.90ozs. doilled and specimens.

doilled and specimens.

† Alluvial.

‡ Includes 56.98ozs

§ By cyanide.

|| Exclusive of alluvial.

## Cosmo Newberry Ranges.

(*Frontispiece.*)

The track to the Cosmo Newberry Ranges leaves the main Laverton to Duketon road at a point about half-a-mile north of Kirkpatrick's Well and runs almost due east from this point for about 45 miles until the Ranges are reached. For the first two or three miles, the country consists of greenstone ridges covered with ironstone conglomerate, then red loamy plains covered with a heavy growth of mulga, these continuing for another three miles, when the main body of granite makes its appearance and runs continuously out to the ranges, the greater part of it being covered by sand plains and spinifex, the granite outcropping through these occasionally as low rough ridges and "breakaways."

As shown on the latest issue of the Lands Department's State Map, these ranges are situated about 60 miles to the north-east of Laverton townsite. They consist of a series of low hills and ridges trending in a general north-north-west and south-south-east direction, and having a maximum length of about ten miles, and a breadth of from three to five miles. At their south end they split into two distinct arms, the more westerly of which runs nearly north and south, and extends several miles farther south than the other. Surrounding this belt of hills on all sides are extensive sand plains covered with spinifex, these being the remains of an old granite tableland. The rocks forming the hills themselves consist of massive and foliated greenstones of the type usually found on the Eastern goldfields; intruded into them are dykes and masses of acidic rocks, which vary from a typical coarse-grained granite to fine compact quartzites and felsites. At Split Rock, which is situated near the western limit of the ranges, there is a considerable extent of granitic rocks outcropping over an area of about a square mile and apparently entirely surrounded by the greenstones, which, however, are for the most part hidden to the westward by a shallow depth of recent detrital deposits. This body of granite dies out about thirty chains north of Split Rock, but a series of acidic dykes run on in a general northerly direction for two or three miles, gradually becoming fewer as they go north. These dykes are found running in all directions, though their more usual trend is roughly north and south; they vary in thickness from a few feet to over a chain. The greenstones are as a rule considerably foliated close to their junction with them, the foliation being parallel to the trend of the dykes; quartz veins and masses are often associated with them, occurring along their junction with the schists, they are, however, seldom of any great size or regularity.

From Split Rock to the Government Well—a line across about the centre of the ranges—a traverse shows the granite extending for



about a mile, then half-a-mile of greenstone schists intersected by numerous granitic dykes, and then massive and foliated greenstones extending to the well, where the schists make their appearance again and continue for half-a-mile or so to the junction with the main eastern body of granite. This eastern junction runs very regularly on a bearing almost due north-north-west and south-south-east, the granite, however, only outcropping here and there over small areas, being for the most part hidden beneath sand plains resulting from its gradual weathering.

About four miles west of the well is what is known as the "Find," this being the first (?) lease worked in this district. The country here consists of foliated greenstones intersected by a few granitic dykes, these being the northern end of the series extending up from Split Rock. Northwards from this line—from the well to the Find—the hills extend for three or four miles, the rocks being mostly massive whilst the acidic dykes are few and far between. The greater part of the hills and ridges over this area are capped with ironstone conglomerate, this being especially the case on the eastern side of the ranges. South from the same line, there are no deposits of this conglomerate, the rocks outcropping on the surface and being very hard and practically unweathered.

In addition to the acidic dykes, a few basic (diabase) dykes intersect the greenstones, one of these towards the southern end of the hills being upwards of a chain in width, and traceable in a north west and south-east direction for over a mile. The greenstones on the whole at the south end of the ranges are more massive than those at the north, and are also intersected by a number of acidic dykes, these usually being a very fine-grained felsite, and on the surface often having very much the appearance of quartz reefs.

Throughout the greenstone area occur numerous quartz reefs; these are for the most part small and very irregular, they are found principally in the schists, in which they occur as lenticular gashes, or series of gashes, running with the foliation and having no defined course and seldom any great length, though occasionally the lenses are of considerable width. The quartz, as a rule, is white and glassy and generally very low in gold contents, although some of the smaller leaders occasionally carry good values. Quartz reefs and masses also often occur in association with the acidic dykes, being usually found along the junction of these latter with the greenstones; they are often of considerable thickness, but are very irregular and seldom extend for more than two or three chains in length, and their gold contents, as far as it was possible to test them, are generally found *nil* to a little better than traces. The district appears to have been pretty well prospected, and almost every quartz reef in the place bears marks of the pick.

Several leases have been pegged out and applied for at different times, but so far no applications have been approved, and with one or two exceptions little or no work has been done on them, neither has any stone been crushed, nor were any of them being worked at the time of my visit. The following, however, is a brief description of the class of deposit on those leases on which any work at all had been done.

[About twenty chains west of Split Rock, several potholes have been put down on a line of reef running on a bearing of about 350 degrees, and apparently dipping steeply to the eastward; these potholes, the deepest of which is only four or five feet, show the reef to consist of white glassy quartz which is strongly laminated; it is about four feet in thickness at the south end and about two at the north, and can be followed in a very regular line for about fifteen chains; it is in a narrow belt of greenstone schist which is enclosed between two acidic dykes and runs parallel to the foliation of the schists. It is about the best defined and most regular reef (on the surface) seen in the district, but is too low grade to pay under existing conditions. A number of samples were taken by myself, and these gave by dish assay results varying from traces to two or three dwts.

Some sixty chains north-north-west from Split Rock a little work has been done on a lease which I was informed had been pegged and applied for under the name of the Kensington. The country here consists of greenstone schists intersected by numerous granitic dykes and masses and is very hard right on the surface; several fair sized irregular lenses of quartz occur alongside these dykes but appear to be of no value; several small quartz leaders also occur in the greenstone schists, and on one of these, occurring in a narrow belt of the schists, a little work has been done. This work consists of two or three potholes sunk to a depth of a few feet, which show the leader to be of an average thickness of about two inches, varying from a mere thread up to five or six inches at its biggest, and running with the foliation of the schists and dipping with them at a steep angle to the eastward; it can be followed on the surface in a not too regular course for only about two chains and, as the best results obtained from it by dish assay were about thirty dwts., some of the samples giving but little better than traces, I do not think it is likely to prove of much value under present conditions, more especially as, from its mode of occurrence, it is likely to cut out at any minute.

Four miles west of the well and about three and a-half miles north-north-west from Split Rock are the leases recently held under option by the Curzon's Syndicate, but at present lying idle. These comprise two twenty-four acre blocks, the Cosmo and the Lord Kitchener, on both of which a little work has been done. The country is mostly greenstone schists intersected by numerous granitic

dykes, these being more numerous in the southern block. On the north block, a vertical shaft has been sunk to a depth of thirty feet on a couple of quartz leaders, two or three feet apart; these, as seen in the shaft, are from 8 to 12 inches in thickness, and run about vertically; the quartz is white and glassy, and a series of samples taken by myself gave by dish assay results varying from traces up to ten or twelve dwts.; these not being good enough to render the proposition a payable one under existing conditions. These leaders run about north-west and south-east, and are only traceable for a short distance on the surface; they appear to me to be merely the fillings of small gashes in the greenstone schists and not likely to be permanent in depth. About half-a-chain east of the shaft is the outcrop of a large white quartz reef running about north and south; this reef is traceable on the surface for a distance of about twenty chains, but is somewhat irregular, and to the south is broken here and there by intrusive granite dykes; its gold contents, as far as tested, appear to be *nil*.

On the adjoining block on the south several potholes have been put down on a quartz leader which appears to be following the junction of a granite dyke with the greenstone schists, and is traceable on the surface for a distance of about two chains. At the north end, a hole has been sunk on it to a depth of about twelve feet exposing a reef twelve inches wide of white glassy hungry-looking quartz, while about a chain to the south of this, a second hole shows it to have pinched to a mere thread. Several samples were taken from it and the best of them only gave results equal to a few dwts., whilst others never gave a trace of gold. The country here is very hard right to the surface, and in view of this fact these small leaders would have to be exceptionally rich to pay to work, especially with the nearest battery forty-five miles away.

There are also one or two other reefs in the locality on which a pothole or two have been put down, but the above are the most important.

Taking the district all through, the reefs are, generally speaking, small and irregular, and so far the best of them have not proved of sufficient size or value to pay for working, and moreover, I am of opinion that very few of them would prove so even under the most favourable conditions.

As regards the watersupply of the district, there is a Government well on the eastern side of the range, the supply from which is, however, very limited, and during the dry season is not more than twenty gallons a day; the well, in order to be of any permanent use, requires to be sunk another twenty feet. Three miles south-south-east from this well is a good soak in a small creek running eastward through the hills; judging by its appearance at the time of my visit, after a protracted dry season, this soak should be, if not drawn too heavily

upon, practically permanent ; we were compelled to resort to it to water our camels during our stay at the Range as there was not a sufficient supply in the well for our own use and theirs. In addition to these supplies, there is a large rock-hole at Split Rock which is capable of holding several hundreds of gallons, and which lasts for some weeks after rains.

There is also a second Government well on the road out, about twenty miles from Kirkpatrick's ; this well, a shallow one, had a good supply of water in it at the time of my visit—there had been good rains a few months before—but is said to occasionally give out after a prolonged dry season.

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## The Country at Mount Shenton and Mount Venn.

Mount Shenton, situated about eighty miles slightly to the east of north-east of Laverton, and thirty miles east of the Cosmo Newberry Ranges, forms the highest point of a range of hills running nearly north and south for several miles and rising abruptly out of the sand plains which surround them on all sides. The main axis of this range is formed by a large belt of hematite-bearing quartz often a chain or more in width and dipping at an angle of about 60 degrees to the east ; this is often considerably contorted and foliated and varies a good deal in its composition, parts of it being almost free from iron, whilst others again appear to be exceptionally rich. The surrounding rock is greenstone schist, and appears to be a crushed and altered quartz diorite.

The full extent of the range is some three miles in length by about half-a-mile in width, the highest point being roughly 250 feet above the surrounding sand plains. The southerly extension of the belt is Mount Grant, a large hill some 250 feet in height about three miles south to south-east of Mount Shenton, formed by a similar belt of hematite-bearing quartz a chain or more in width and dipping at an angle of about 60 degrees to the east ; intermediate between the two hills, the belt outcrops in one or two places in the form of low hills and is apparently continuous right along, though the greater part of it is hidden beneath the sand plains.

There appear to be no quartz reefs in the Mount Shenton greenstones, neither are there any associated with the main hematite-bearing quartz lode, and this, as far as tested, appears to be practically free from gold.

Eastward from Mount Shenton, the sand plains continue for a distance of about three miles when there is a fairly extensive outcrop of granite, the plains then extending on eastward indefinitely; this outcrop is in the form of low bare hills and ridges, the general trend of which is about south-south-east and which extend almost continuously to the neighbourhood of Mount Venn, where there is a much more extensive development of them than at the north end. This granite is a coarse-grained pink coloured variety and appears to be newer than and intrusive into the main body of granite which occupies the greater portion of the eastern half of this State, and the denudation of which has resulted in the formation of the great sandy tablelands of the interior; there is, however, no direct evidence on this point either one way or the other, but there is, near Mount Grant, a considerable area of granite porphyry which appears to be closely allied to this body of granite, and which is undoubtedly newer than both the main body of granite and the greenstones.

These granite hills form the eastern boundary of the greenstone ranges of which Mount Grant and Mount Venn are the highest points, the general trend of this junction being about south to south-east; the hills, however, die out just before Mount Venn is reached and give place to sand plains extending easterly and south-easterly indefinitely.

The length of the range of hills which includes Mount Grant and Mount Venn is roughly some seven miles, but its lateral extent is very irregular, varying from a maximum of about five miles down to half-a-mile, and having an average of less than two miles. The rocks comprising them are greenstones intersected by masses and dykes of acidic rocks, these latter being largely developed a little to the south-east of Mount Grant, where there is an area of them over a mile in extent consisting of a fairly coarse-grained quartz porphyry apparently closely related to the large body of granite a little farther east; southward of this, towards Mount Venn, are numbers of felsite and granitic dykes often of large size running in all directions through the greenstones. These greenstones are both massive and foliated, the latter variety being most largely developed at the northern end, where it is a crushed diorite similar to that of Mount Shenton. In the vicinity of Mount Venn, the rocks are entirely massive and consist of a coarse-grained augite rock very different to the usual type of greenstone; a section of this rock [6569] shows it to consist of augite and plagioclase feldspar in about equal proportions, the former being the typical colourless to light brown variety in large flakes and masses some times showing alteration into pale green fibrous uralitic hornblende; the feldspars are principally labradorite, and have a strong tendency to idiomorphism, with columnar and occasionally tabular habit; twin lamellation occurs on both the albite and pericline laws, the latter only occasionally, however; a few small crystals of magnetite are

PHOTO. 17.

Bulletin 24.

GEOLOGICAL SURVEY.

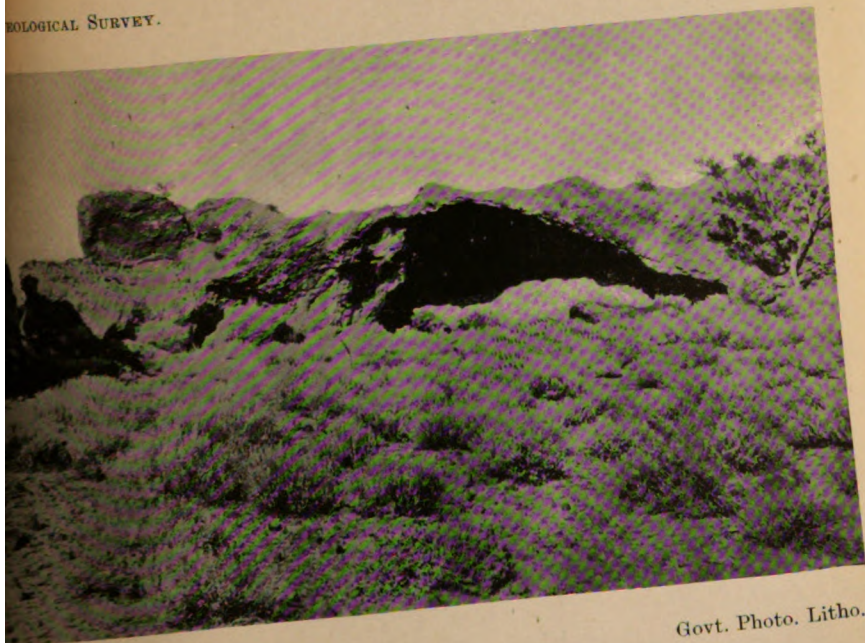


Photo., C. G. Gibson.

Weathered Granite near Mount Warren,

Govt. Photo. Litho.









Photo., C. G. Gibson.

Govt. Photo. Litho.

**Weathered Granite near Mount Warren.**





also present. The rock is very little altered and is extremely hard and solid right to the surface, this being characteristic of all the rocks in this district.

Quartz reefs are few and far between, what there are being mostly towards the northern end of the belt, and these are small and of no extent, being merely the infillings of small gashes in the greenstones; the quartz is white and glassy and, judging by the results obtained from dish assays of a large number of samples taken by myself, is extremely low in its gold contents, most of the samples giving blank results, and the best of them only a few dwts.

This belt of country (from Mount Shenton to Mount Venn) is very poorly watered. Three miles from Mount Shenton, on a bearing of 67 degrees from it, is a soak at the north end of a bare granite hill; this, although it was dry at the time of my visit, after an exceptionally dry season, could, after a fair season, be generally depended upon to contain water during the greater part of the year, but the supply would be very limited. Another soak is situated amongst some low granite ridges about 5 miles on a bearing of 132 degrees from Mount Shenton and  $2\frac{1}{2}$  to 3 miles on a bearing of 46 degrees from Mount Grant; as we obtained a small supply of water here, after sinking about twelve feet, this soak may be considered almost permanent, but the supply is small, except after good seasons. These appeared to be the only two soaks of any importance in the locality.

**MOUNT WARREN AND MOUNT CUMMINGS.**—These hills are situated about 30 miles north-east of the Cosmo Newberry Ranges and 90 miles north-east of Laverton. They form the two highest points of a range of hills running about north-west and south-east and occupying an area about five miles in length by three in greatest breadth, and rising to a height of some 200 feet from the sand plains which surround them on all sides, and are known to be continuous from Cosmo Newberry and Mount Shenton to Mount Warren and north and easterly as far as the eye can reach, being only broken by occasional low rough granite ridges. The rocks forming this range of hills consists of fairly coarse-grained greenstone (diorite) and are mostly massive, a little foliation being noticeable on the eastern and north-eastern sides where they come in contact with the main body of granite which underlies the surrounding sand plains.

As far as I was able to ascertain in a brief examination, owing to the scarcity of water, there appear to be no quartz reefs whatever within this area of greenstones, the only reef seen being a large white quartz contact reef along the junction of the greenstones with the granite on the north-eastern side of the hills; this reef is over a chain in width in places and is traceable on the surface for over half-a-mile; so far as tested its gold contents are *nil*.

The locality is badly off for water, there being only one soak in the neighbourhood and that not a particularly good one; during

my visit there, being short of water, we sank on this soak to a depth of about twelve feet but, obtaining only a few pints of water, were compelled to leave it and return to Cosmo Newberry. After a fair season, however, I think this soak could be depended on for a fair supply, but the locality is a good one for prospectors to keep away from.

The above localities, together with the Ulrich Range, are the only areas of possible auriferous country within the district examined, a district extending from thirty miles or so south of the Cosmo Newberry to as far north as the south end of Lake Wells and easterly to twenty miles beyond Mount Shenton. The whole of this area, with the above exceptions, is occupied by broken granite tablelands and sand plains, the former often being found with weathered vertical cliff faces 50 feet and more in height, locally known as "breakaways"; the sand plains represent the denuded and weathered remains of similar tablelands and occupy by far the greater part of the eastern portion of this State.

## The Ulrich Ranges.

In addition to the localities already described, a short visit was paid to the reported new find at the Ulrich Range on the south-east side of Lake Wells and about 60 miles east-north-east of Duketon, and a report made as to its extent and probable resources.

The workings are situated on the north-eastern side of a low rough ridge of greenstone hills, trending in a general north-west and south-easterly direction for five or six miles, and having a maximum width of a little over a mile, tapering to nothing at either end; these hills are entirely surrounded by sand plains and spinifex. The rocks which comprise this ridge consist of fine to coarse-grained massive and foliated greenstones (amphibolite), similar to those usually found forming the auriferous series of the Eastern fields; these are traversed by a large number of acidic dykes, varying from a coarse-grained granite to a fine, compact, quartz porphyry, the latter type being by far the more prevalent. These dykes vary greatly in size, and run in all directions, though the majority of them have a general north and south trend; they also appear to be newer than the quartz reefs which they frequently cut through; the greenstones are usually considerably crushed and foliated in close proximity to them. The north-eastern fall of the hills is into a long narrow arm of salt lake—probably part of Lake Wells—lying from about two miles away.

This lake runs past the north-western end of the hills, and then turns and runs southerly, being crossed by the road about six miles west of the "find."

The present workings are situated on a small gully running down the eastern fall; this has been worked at irregular intervals for a length of about 20 chains, and a good deal of work has been done. Most of the gold has been got in the wash right in the bed of the creek at a depth of from two to four feet from the surface, and usually at points where the gully is crossed by the granitic dykes which form natural riffles on the bed of the gully. No, or very little, gold has been got on the fall of the hills into the creek; and this fact, viz., that all the gold has been shed and carried into the bed of the creek, militates against the chance of any rich leaders being found. So far most of the gold found is pretty fine, the largest piece obtained being less than 10 dwts. No specimens have been obtained, but one or two pieces of gold were found with small pieces of ironstone attached, which would show that the gold has been shed from a small ironstone leader, or leaders, in the greenstones, which has been completely denuded away. There are several other gullies in the hills, and these have all been tried for alluvial, and so far with negative results; the sides of the hills and the flats at the foot of them have also been tried in numerous places with similar results. At the time of my visit there were seven men at the "find," one of whom was employed in carting water from the soak 20 miles distant by road, the remaining six were engaged in alluvial working, and had obtained amongst the lot of them between 15 and 18 dwts. of gold as the result of a week's work. These men professed themselves as very dissatisfied with the district, and gave it as their intention to leave the place within the next few days. On my way into Duketon I passed another party of five on their way out to the "find"; this will make quite a sufficient number of men to thoroughly test the locality, if that has not been done already.

While at the "find" I saw several runs put through the shakers, and all of them with very disappointing results, mostly only a couple of small "colours." A party of four who were at the "find" some weeks before the present party, obtained 8ozs. 7dwts. of gold as the result of six weeks' work; while, in addition to this, one man got from 28 to 30dwts., but I was unable to ascertain how long it took him to get this amount.

This district was originally prospected by H. Swincer, who is said to have obtained a little alluvial gold here about four years ago; a couple of years later, Kirkpatrick and party, as the result of several weeks' work, obtained a few ounces of alluvial gold; I was unable to ascertain the exact amount, but it was said to be somewhere about 10ozs.

As regards the reefing possibilities of the district, I do not think anything of importance is likely to be found in this line. Quartz reefs are certainly fairly numerous, but they are small and very irregular, being for the most part merely short lenses or gashes running with the foliation of the greenstones, and are, I think, not likely to live to any great depth; they are also much broken and distorted, owing to the intrusions of granitic dykes. The quartz is white and glassy, and, as far as tested, very low in its gold contents; a large number of samples were "dollied" by myself, and the best result obtained was only slightly better than a trace, most of them being blanks. There is, however, one fairly well-defined line of reef—or, rather, line of lenses—traceable on the surface in a north and south direction for a distance of about 10 chains, the largest continuous length of quartz being about 60 feet, and having a maximum width of about three feet; it is, however, broken in several places by granitic intrusions, and the lenses of stone are likely to behave just as irregularly vertically as they do longitudinally.

The stone in this line is the typical white glassy quartz, and near the north end has a considerable quantity of carbonate of copper associated with it, as well as occasional small pockets of galena. This line was carefully sampled by myself, and a large number of samples dollied, the best prospect obtained being equal to about 1 to 2 dwts. per ton. A few of the samples gave traces of gold, but the majority of them were blanks.

Almost every one of these reefs show signs of having been sampled several years back, and the area of possible auriferous country is so restricted that two or three men could thoroughly prospect it, from a reefing point of view, in a couple of weeks, and I am of opinion that this has already been done. The country rock is extremely hard right on the surface, and under existing conditions, *i.e.*, with the nearest battery 60 miles away, and over heavy sand at that, reefs would have to be exceptionally rich to be of any use to the prospectors, and I do not think there are any reefs of this description in the locality; and, in my opinion, even if the reefs were of fair grade, there is nothing of sufficient size or regularity to warrant even the thought of erecting a battery on the spot.

With regard to other possible finds in the vicinity, from personal observations, there is no auriferous country to the south until the Cosmo Newberry Ranges are reached; none south-easterly till Mount Warren—and this is an exceedingly poor belt; and none westerly or south-easterly till the Duketon-Erlistoun belt. To the north and north-east, beyond Lake Wells, low granite ranges and sand plains extend as far as can be seen, and these are said to extend in this direction for practically an unlimited distance.

GEOLOGICAL SURVEY.

PHOTO. 19.

*Bulletin 24.*



Photo., C. G. Gibson.

Govt. Photo. Litho.

**Granite Rocks near Cosmo Newberry.**









Photo., C. G. Gilson.

Govt. Photo. Litho.

**Rockhole in Weathered Granite, 30 miles S.E. of Cosmo Newberry.**





As to the water supply of the locality, a well has been sunk on the eastern fall of the hills, about a mile and a-half from the lake, in which water was struck at about 30 feet. This water is, however, too salt to be of use even as stock water. If a well was put down on the other fall, I think the chances are that this would probably be salt too, as the lake runs round this side of the hills as well, though at a somewhat greater distance—about six miles. I do not think a permanent fresh water well is likely to be found in the locality. The present water supply is from a soak in a small creek eighteen direct miles from the “find” along the Duketon road; water has to be carted from here to the “find” over heavy sand, and the supply is only very limited, and unless replenished by rain is not likely to last many more weeks. Between this and Duketon there is no water except at a rock hole six miles from the soak; this, however, is most probably dry by now as there were only a few gallons of water in it early in November.

I am hardly of opinion that the “find” is of sufficient promise to warrant the Government going to the expense of putting down wells along the road, but if these are sunk, almost the only places where they could be put would be (1) on the cork tree flat, 16 miles from Duketon, and (2) on the creek, a little below the present soak, and I am not in great hopes of a supply being obtainable at either place, especially at (1)—that is in shallow wells. If these wells are put down—and this applies to all shallow wells in the out back country—I would very strongly advise that they should be sunk in the summer season, for if a supply is met with, then it can fairly safely be relied upon as permanent, whereas if they are put down in the winter—usually the wet season—a fairly heavy supply of soakage water is often met with which goes dry, or nearly so, before the dry season is over, and this is often a very serious matter in that part of the State. The Cosmo Newberry Government No. 2 Well is a case in point; this well is now only making a few gallons of water per day, and that only after it has been sunk another five or six feet by private parties.

CHAS. G. GIBSON, B.E.

Assistant Geologist.

## Appendix I.

List of rock specimens collected in the Mount Margaret Goldfield.

Registered No. of Specimen.	Registered No. of Micro-plates.	Description of Specimen.	Locality of Specimen.	Remarks.
6326	692	Hematite-bearing quartz	1 mile west of Enniakillen, Laverton	See page
6327	693	Massive amphibolite	1 mile south-west of Enniakillen, Laverton	See page
6328	694	Massive greenstone (diortite)	G.M.L. 777, Laverton	See page
6329	..	Felsite	G.M.L. 777, Laverton	See page
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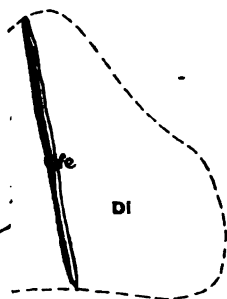
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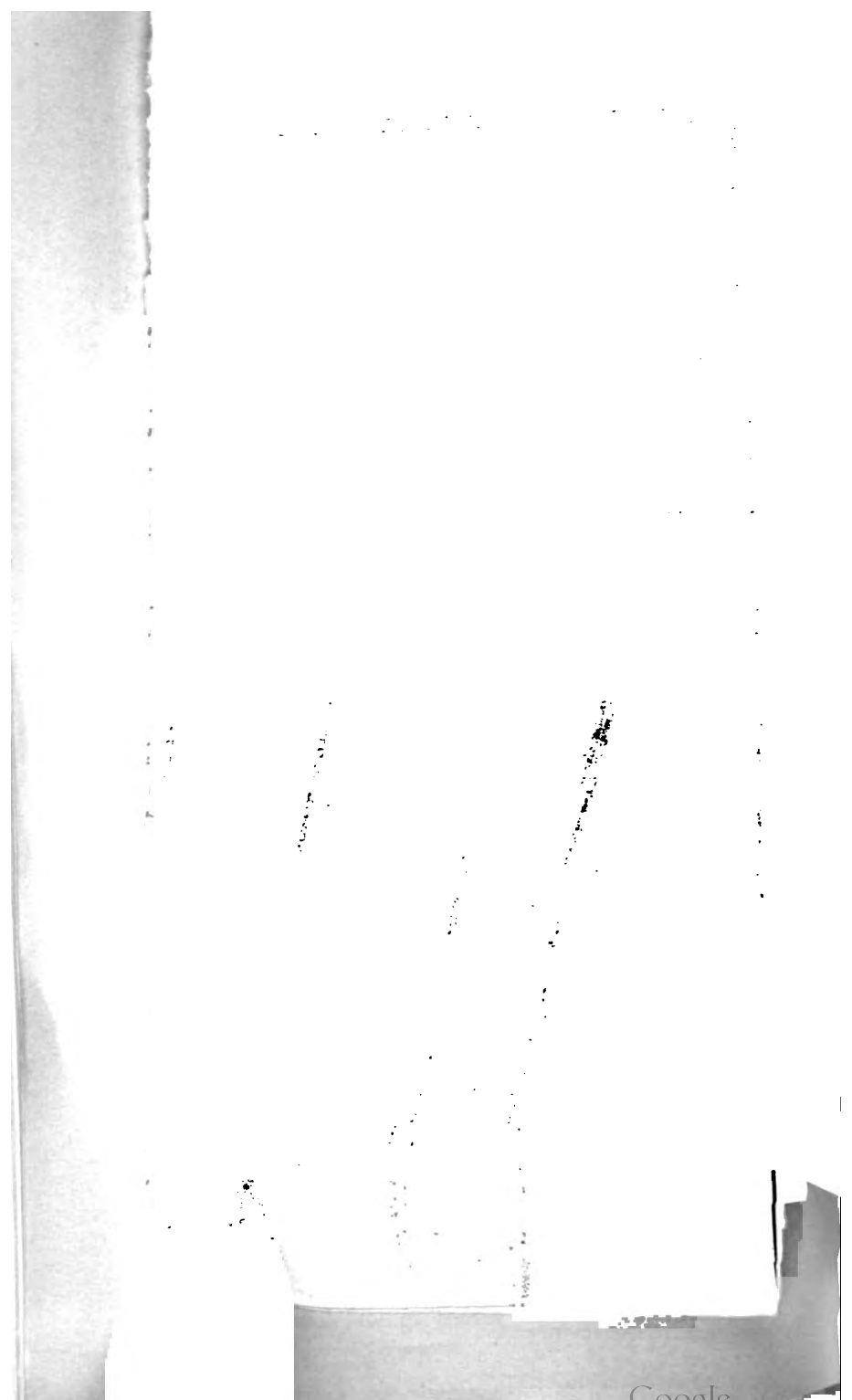
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Government Geologist.*



*C. B. Kidson  
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Government Lithographer. Perth. W. A.





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*A Little Maitland  
Government Geologist.*

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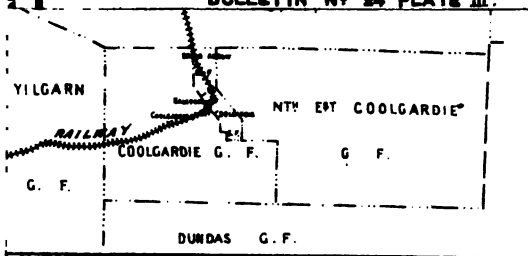
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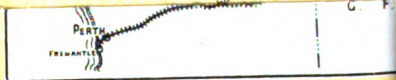
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1906,  
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WESTERN AUSTRALIA.

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# GEOLOGICAL SURVEY.

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BULLETIN No. 25.

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## THE PROSPECTS OF OBTAINING ARTESIAN WATER IN THE KIMBERLEY DISTRICT.

BY

R. LOGAN JACK,

LL.D., F.G.S., F.R.G.S.

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*Issued under the authority of the Hon. H. Gregory, M.L.A.,  
Minister for Mines.*

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WITH A GEOLOGICAL MAP.

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PERTH:

BY AUTHORITY: FRED. WM. SIMPSON, GOVERNMENT PRINTER.


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1906.



## PREFATORY NOTE.

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 DURING to there being no officer of the Geological Survey Staff available, Dr. Jack was specially commissioned by the Public Works Department to report upon the prospects of obtaining artesian water in the Kimberley Division.

His report, and the explanatory map, on being submitted to the Government, were ordered to be printed for public information, as one of the series of the Geological Survey publications.

The index to names, places, etc., occurring in the report has been prepared by Mr. P. J. Atkins, Clerk of the Geological Survey.

A. GIBB MAITLAND,  
Government Geologist.

Geological Survey Office,  
Perth, 16th July, 1906.



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Geological Map ... ..	At the end.
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## The Prospects of Obtaining Artesian Water in the Kimberley District.

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I beg to report that, in accordance with my instructions, I left Perth and Fremantle on 29th October last and reached Wyndham by sea on 13th November. After making an examination of the neighbourhood of the township, and having completed my arrangements for the journey, I left Wyndham on 20th November, making for Derby overland, by a route determined by the object of the inquiry. Having arrived at Derby on 9th January, I embarked on the 17th and reached Perth on the 27th.

The details of the overland journey are given in the "Itinerary" appended to this Report, and may be followed on sheets 128, 135, and 141 and 142 of the 300-Chain Map,\* which have been geologically coloured; a reduced map on the scale of 12 miles per inch is attached. The main route amounted to 714 miles, with excursions by buggy, on horseback, or on foot, amounting to about 50 miles more. To the Itinerary there are added notes on the water supply at the camps (43 in number) and at various points along the route. These notes may be of service to future travellers, as they represent the actual condition of things during the severest drought which has yet been experienced by the white settlers of the district. The maps of the Lands Department show numerous pools and "springs" which I found dry, and which are not to be relied on except in good seasons.

The "wet season" of 1903-4 had been more or less a failure all over the district, and that of 1905-6 was, at the time of my visit, overdue, so that I saw the country at what it is to be hoped was a very worst. "Dry" camps, to which we had to carry water, had to be made if there was a prospect of feed for the horses. At other camps, we had to "spell" in order to allow the horses to recover from the effects of starvation stages behind, or to fortify themselves for similar stages in front of them. Moreover, as the intense heat (reaching 114 degrees F. and generally well over 100) made it impossible to work the horses between 10 a.m. and 3 p.m. without danger to their lives, valuable time had to be wasted. Under the circumstances, the route aimed at had often to be abandoned in favour of one determined by consideration of grass and water, and visits to certain desirable places had to be abandoned because

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\* Lands Department Lithographs, 1904.

neither of these necessities was to be met with. We were, however, so far fortunate in that we now and then found water from local showers, although these had been either too light or too recent to produce any "spring" in the grass, while in the latter part of the journey rain had fallen long enough before we arrived to make feed abundant, and we suffered little inconvenience beyond an occasional wetting. None of the large rivers which lay across our path had begun to flow.

The main route (which is laid down on the maps) running south-east from Wyndham, touching the Northern Territory south of the 16th parallel, thence proceeding southward on the Western Australian side of the border to 16 degrees 25 minutes south latitude, south-westward to Hall's Creek, the metropolis of the Kimberley Goldfield, and westward and north-westward to Derby, kept, with slight exceptions, within the drainage areas of the two great rivers, the Ord and Fitzroy and their tributaries. The only inhabited places passed on the way were Goose Hill, Ivanhoe, Argyle, Rosewood, and McKellar's Stations, Argyle (Wild Dog) Police Station, Springvale, Texas, Ord River, Nicholson and Flora Valley Stations, Hall's Creek township and telegraph office, Langley's and Fossil Hill Stations, the Fitzroy telegraph office, the Fitzroy Crossing police station and hotel, Oscar Range, Balmaningarra and Meda Stations. Although considerable portions of this track are, as a rule, only used by travellers on horseback, the whole of it may be set down on the map as practicable for vehicles—provided the passengers carry with them a pick, shovel, and axe.

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## Geological Formations.

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- S. Carboniferous Sandstone.
- L. Carboniferous (?) Limestone.
- D. Devonian Sandstone, Grit, and Limestone.
- M. Metamorphic Rocks :—Slates, Schists, Gneisses, etc. (Silurian, Cambro-Silurian or Cambrian).
- G. Granite.
- B. Basalt.

The pioneer geological observer was Mr. Edward T. Hardman, of H.M. Geological Survey of Ireland, who, in 1883 and 1884, accompanied the "Kimberley Survey Expedition," under Mr. Harry F. Johnston, now Surveyor General. Starting within a few days of his arrival in the colony, without any previous acquaintance with

the Australian bush, and practically without maps—since the expedition was only laying the foundation of the excellent topography now available—Mr. Hardman, with a keen eye and intuition amounting to genius, sketched on broad lines the geological features of the district, at the same time pointing out its economic importance. It is true that the Kimberley Goldfield to which he directed attention has not taken, and may never take, a high rank, but his writings attracted the men whose further prospecting has resulted in Western Australia occupying a leading place among gold producers. He wrote two reports (1884 and 1885) "On the Geology of the Kimberley District," accompanied by two geological maps, the first embracing the district from Broome, *via* Derby, to Mount Fairbairn, and the second that from Mount Fairbairn north-eastward to the Northern Territory in latitude 17 degrees south. Although both reports and maps are of extreme value, they bear internal evidence that the printing had not the advantage of the author's supervision.

In 1891, Mr. Harry Page Woodward, then Government Geologist, traversed the country between Wyndham and the Goldfields, his observations supplementing those of Hardman, especially to the north and by a route west of my own, so that geological lines can be extended with confidence.

In 1901, Mr. A. Gibb Maitland, Government Geologist, went out in search of an alleged area of auriferous country between the 15th and 16th degrees of south latitude. No detailed report has yet been issued, but a synopsis is given in the Annual Report of the Geological Survey for 1901. Although Mr. Maitland's travels demonstrated the absence of the expected auriferous region, they were, as will be seen later, of high importance in their bearing on the question of artesian water.

### Carboniferous (S.,L.).

This formation, as understood by Hardman, is divisible into an Upper or Sandstone (S.) and a Lower or Limestone (L.) series. The latter he describes as having been observed by him to be succeeded conformably by the former at the Haughton Range in latitude 19 S. and longitude 127 E. (Second Report, p. 27). All that I have seen is consistent with this order of succession. Hardman does not intend to convey, nor do I, that the Sandstone member consists entirely of sandstone, or the Limestone member of limestone. In the one, however, sandstone and other purely sedimentary rocks prevail, while in the other limestones predominate.

The *Upper or Sandstone series* (S.) was first seen by me at Wyndham and thence northward down the west arm of the estuary which widens out into Cambridge Gulf. It may be regarded as typically developed in the Bastion Ranges, at Wyndham. In these ranges,

which attain a maximum elevation of 1,068 feet, escarpments of sandstone present their steepest faces to the north-west, and dip at a low angle, say seven degrees, to the south-east. Eastward, similar rocks (House Roof Hill, etc.) extend to the border of the Northern Territory. They are divided from rocks which I regard as Devonian by an east and west line running south of Wyndham and the "House Roof Crossing" of the Ord (*see* Sheet 142\*). Mr. Maitland informs me that the Wyndham beds extend as a continuous formation westward to the mouth of the Prince Regent River, and have a prevailing dip to the west.

The sandstones themselves are white, although they frequently weather red or yellow, and are sometimes almost hard enough to deserve the name of quartzites. With them are associated shales, which form the bulk of the hills open to observation, although from their softness they are less conspicuous than the sandstones. The shales, so far as my observation goes, are absolutely unaltered, and are of the usual blue, grey, and black Carboniferous type, although they may weather to red or yellow.

In Sheet 141\* only a very small area of the Upper Carboniferous rocks is met with between Mount Brooking and the border of the Northern Territory. Seventy miles farther to the south (Sheet 132\*) the Upper Carboniferous forms the broken tableland of which Mount Elder is the most conspicuous fragment. The tableland lies between the Negri and Ord Rivers, both of which expose the underlying "Limestone" series. West of the Ord, the sandstones extend from the Glass Hill to the Dixon Range, presenting long cliffs surrounded by high "downs."

The formation is next met with at Flora Valley Station, east of Hall's Creek (Sheet 131\*) where the sandstones rise to considerable elevations in Gullana Hill north and Mount Timperley south of the station, and the shales form open "downs."

Granite and Metamorphic and Devonian rocks, all older than Carboniferous, occupy the next 160 miles to the west along my route, and it is not till a few miles below the Fitzroy Crossing that the Upper Carboniferous formation re-appears. Here it is seen in juxtaposition to the Limestone or Lower member of the formation, and there is no reason to doubt that the latter underlies the former, as was observed by Hardman at Mount Abbott to the south-east. The line of demarcation between the two runs to the north-west, along the flanks of the Oscar and Napier Ranges, an enormous area of "pindan" country, diversified by sandstone tablelands, marking the extension of the Upper or Sandstone series of Carboniferous rocks from the George Range to Derby.

The *Lower or Limestone Member* (L.) of the series is not met with north of the Negri River. It occupies the valley of that River

\* Lands Department Lithographs, 1904.

to the east of the Mount Elder Tableland, where it rises into Mount Panton (Northern Territory), and forms high "downs" up the valley of the Ord from its junction with the Negri south-westward to a point about five miles beyond the Hardman Range where it rests on bedded basalts.

From the "Rough Range" (Sheet 130\*) north-westward to the Napier Range (Sheet 134\*) the limestone series attain a most remarkable development. The Oscar Range, as seen from the south-west, shows a rectilinear rampart of limestone, 47 miles in length, which has all the appearance of being the edge of a horizontal tableland. This impression, however, is found, on close inspection, to be erroneous, as the limestone of the rampart is seen to rest unconformably on the slates and schists which compose the core of the range, and to dip to the south-west at 30 degrees. My route in this locality followed the telegraph line, which is carried along the flat at the foot of the "rampart." In this flat the dip of the limestone beds is seen to decrease to 15 and even 10 degrees, and there is every reason to believe that the limestones pass under the sandstones on the south-west side of the telegraph line. In the Geikie, Hull, and Rough Ranges (Sheets 129 and 130\*), the outcrop of the Limestone series is many miles in breadth.

The Sandstone series, according to Hardman (Second Report, p. 25), contain an assemblage of fossils undoubtedly Carboniferous. The list from the Limestone series comprises fossils equally Carboniferous (Loc. cit., p. 26). Mr. H. A. Foord, however, in the *Geological Magazine* for 1900, describes several *Devonian* fossils presented by Hardman to the British Museum before his death. The fossils in question, according to the labels, came from the Rough Range and Mount Pierre, localities from which many of his Carboniferous fossils were derived.

At Minnie Pool (Sheet 130\*), near Mount Pierre, I observed some indication that the limestone region mapped as Carboniferous consists partly of limestones of an older date. At the head of the Pool is a well-bedded limestone dipping to the west at 25 degrees. Between this point and the hill a quarter of a mile to the south, vertical beds of mica schist with a north and south strike are met with. The hill itself is composed of a limestone in beds which dip to the south-east at 80 degrees. Its strong *Devonian* aspect struck me at once. Some layers were almost entirely composed of corals in very bad preservation, but after a good deal of searching I obtained three specimens which I sent to Mr. Robert Etheridge, Director of the Australian Museum, Sydney. Mr. Etheridge writes that the corals are *Stromatoporoids*, and are, therefore, either *Silurian* or *Devonian*, certainly not *Carboniferous*.

There is always the possibility that Hardman's determinations—apparently made in the field—were less accurate than those of

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\* Lands Department Lithographs, 1904.

a palaeontological specialist to whom the whole of the literature of the subject and the collections of museums are available. At the same time, I do not question his ability to appreciate the significance of the general *facies* of the assemblage of fossils with which he was dealing. Either there are, in the locality in question, separable Carboniferous and Devonian strata, or the same strata contain a Devonian-Carboniferous, just as certain formations in the Eastern States contain a Carboniferous-Permian fauna. Any fuller discussion of this question would be out of place in a report dealing with the specific question of artesian water, on which it has no practical bearing.

#### Devonian (D).

A formation clearly older, more highly metamorphosed, and more violently contorted than the Carboniferous, and yet neither so much metamorphosed nor so violently contorted as the slates and schists of the Goldfields, was provisionally referred by Hardman to the Devonian. It consists mainly of indurated sandstones, with beds of limestone. The sandstones are frequently so altered by the solution and redeposition of their silica that their original texture is either wholly obliterated or can only be recognised by following lines of coarser or finer grains, and in places may justly be designated "quartzites." Hardman first met with them in the south-western face of the King Leopold Ranges, which he followed from north-west of Mount Broome (Sheet 134\*), south-westward to Mount Huxley and Mount Fairbairn (Sheet 130\*). In this region, my route (in the opposite direction) joined his at Mount Fairbairn, where the sandstones have suffered (so far as I am aware) the extreme of metamorphism in the direction of quartzite. It is not surprising that he should have begun by classing this quartzite as part and parcel of the altered rocks of the Goldfields, and, as a matter of fact, in his first report and first map he did so. Subsequently, however, as he travelled east and north-east, he classed, in his second report, the same rock in the Albert Edward Range (where it is less altered) as Devonian. But for the absence of opportunity for revision and his untimely death, he would, in all probability, have altered his first map in accordance with the results of his newer observations.

In my traverse, the Devonian rocks were first met with at Goose Hill, 12 miles from Wyndham (Sheet 142\*), and they occur to the south of a line drawn from that point eastward to the Northern Territory. They form the ranges on the left bank of the Ord River west of the Ivanhoe Stud Station, as far south as the slopes of Mount Hensman (Sheet 141\*), where they abut on, and are evidently divided by, a fault from the "Siluro-Cambrian" slates and schists of the Carr Boyd Ranges. From Mr. Woodward's traverse, we are enabled to extend their area to the Saw and Deception Ranges,

\* Lands Department Lithographs, 1904.



about 40 miles to the west. On the line of my traverse, they have a general dip to the east at about 30 degrees, while in the Saw Range they are highly contorted and dip to the north-west at 70 degrees. Where I saw them they were hard and quartzite-like on the surface, but when broken presented no very marked appearance of metamorphism.

So far as I could make out from my route, which here took me farther to the east, Mount Brooking and Mount Misery form a Devonian mass on the south-eastern side of the Carr Boyd Ranges. Woodward notes the occurrence of "Devonian Ridges" east of McPhee Creek, at and south of Trig. Station C.N. 8, and in this locality the Devonian rocks apparently rest on granite.

Farther to the south I traced a "wall" of highly inclined limestone from Rosewood Station south-westward to the Behn River, and was informed by Mr. F. C. Hill, of Lissadell Station, that it can be traced south-westward to near Mount Pitt, a total distance of about 45 miles. A similar "wall" runs south-south-west from the "Sugar Springs" for about 10 miles. Both of these masses stand up in the midst of basaltic "downs" precisely as if they were dykes or veins. It would, of course, be absurd to imagine them to be either the one or the other, and I can only suppose that they are "knife-edge" ridges of the old land surface, over the lower denuded portions of which the molten basic lavas were poured.

The Osmond Range, extending for about 40 miles south-west of the Negri River (Sheet 132\*), although I only saw it from a distance, is obviously composed of rocks dipping south-south-east at 30 degrees, and identical with those of the Ivanhoe Stud Station, and I have no hesitation in mapping it as Devonian. It lies between gneisses and schists (Woodward) on the north-west and the Carboniferous rocks (Upper and Lower series) of the Ord Valley. In all probability some of the ranges between Osmond and Turkey Creek are of the same age.

\* The Albert Edward Range, occupying the left (west) bank of the Elvire River (Sheets 131 and 132\*), and flanked on the west by the slates, schists, etc., of the Goldfield, is composed of grits, sandstones, shales, and limestones. The sandy beds which greatly predominate, are somewhat indurated, but cannot, except occasionally, be spoken of as "quartzites." The strata have a prevailing south-south-westerly dip, varying from 20 to 45 degrees, and frequently coincident with the slope of the eastern side of the range.

The Hardman Range (Sheet 132\*), is composed of rocks identical with those of the Albert Edward, although coloured on Hardman's map as Upper Carboniferous limestone "downs," and is evidently a portion of an old land surface too high to be covered by the deposit of Lower Carboniferous limestone. It is impossible

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\* Lands Department Lithographs, 1904.

to explain, otherwise than by hurried observations. Hardman's identification of this range with the Upper Carboniferous. The range is composed of indurated sandstones precisely similar to the rocks of the Albert Edward Range, which he has mapped as Devonian, and absolutely unlike anything which he has mapped elsewhere as Carboniferous.

From the Albert Edward Range westward through the slates of the Hall's Creek Goldfield and the granite which divides the Elvire and Laura drainage basins, nothing more is seen of the Devonian formation. It re-appears, however, in a low range west of the head of the Laura (Sheet 130\*), where it consists of indurated sandstones of the Albert Edward type. Hardman maps it as "quartzites and altered grits" of Lower Silurian or Cambro-Silurian age, and includes Mount Barrett, to the north-east, in the same mass. Although I have only seen Mount Barrett from a distance, it is so obviously different from the indurated sandstones of the head of the Laura that I hesitate to regard it as of the same age.

The Ramsay Range (Sheet 130\*), composed, according to Hardman, of "hard red grits," is mapped by him as Devonian. As seen by me from the north-east it appeared to be identical with the Laura mass, the strata dipping at 20 degrees to the north-west.

Masses of granite, gneiss, and schists intervene between the Laura and Dead Horse Creek (241 mile post of the telegraph line), where the next outcrop of the Devonian rocks is crossed. This place is on the summit of an anticlinal arch, the indurated sandstones dipping to the north to form the Mueller Range and to the south to form low hills which have not been dignified with a name. Farther west, it will be noticed that the indurated sandstones of the Mueller Range, dipping to the north-west, are absolutely continuous with those of the Lubbock Range dipping to the south-east. Hardman has, however, mapped the former as "quartzite and altered grit" of "Silurian or Cambro-Silurian" age, and the latter as Devonian. In his report Hardman insists on the identity of the Mueller Range with the King Leopold Range, with which I entirely agree, in so far as the southern end of the latter (which is all that I have seen) is concerned. In my view, the Lubbock Range and the Mueller Range (and therefore the King Leopold Range) are newer than the "Silurian or Cambro-Silurian" rocks of the Goldfields, and identical with the Albert Edward Range, which I agree with Hardman in calling Devonian.

Mount Bertram, west of the Lubbock Range, consisting of "hard brown grits and flags, with slates and limestones rolling at high angles," is also mapped by Hardman as Devonian.

The gorge of the Margaret River, dividing the Mueller from the King Leopold Range, shows beds of white hardened grits, dipping

\* Lands Department Lithographs, 1904.

at high angles to the north-west. About ten miles farther, similar sandstones, indurated to the point of being almost quartzites, form a sharp anticline, the strata on the north being part of the King Leopold Range and those on the south being almost immediately faulted against a granitic mass.

Lest it should appear that the above remarks are mainly a criticism of Hardman's report and maps, I should like to make it clear that no one is more fully aware of their value than I am. At the same time I may say that, if I have made corrections, I believe that they are only such as, had Hardman lived to review his completed labours, he would himself have made. The advantage which I had over him in having in my possession fairly reliable maps, while he had practically none, is one which only a field geologist can fully realise.

### Silurian, Cambro-Silurian, or Cambrian (M).

Large areas of metamorphic rocks, slatey, schistose, and gneissic, were provisionally regarded by Hardman as Lower Silurian or Cambro-Silurian, and in these occur the auriferous veins of the Kimberley Goldfields. There is little physical evidence as to their age, beyond the fact that they are overlaid by Devonian rocks. The palæontological evidence is also exceedingly meagre, and, scientifically speaking, ought to be ignored, as the two localities from which Hardman collected Cambrian fossils (*Salterella Hardmani* and *Olenellus ? Forresti*), have been defined too vaguely for identification as "Kimberley District" and "River south of Base Line." As the only way in which these rocks affect the question now at issue is that they cover an area in which artesian water is not to be expected, they may be passed over with the mere record of where they occur.

They were first met with by me at Mount Hensman (Sheet 141\*), and it is believed that they form the whole or the greater part of the Carr Boyd Ranges. Next they form a broad belt extending between the granite of the upper waters of the Ord on the north-west and the Devonian and Carboniferous rocks on the south-east, from the Negri River south-westward to, and beyond, the Hall's Creek Goldfield and the McClintock Range (Sheets 132, 131, and 130\*). Isolated patches are met with in the Laura and Margaret valleys (Sheet 130\*), where, at least in some instances, they pass into granites. They then, according to Hardman, form a broad belt extending to the north-west from the Margaret River near Mount Krauss to Mount Amy on the Barker River (Sheets 130, 133, and 134\*). This area, which includes the auriferous rocks of Richenda, is beyond my personal knowledge, with the exception of part of the Oscar Range, where the slates, etc., underlie the Carboniferous (?) limestone.

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\* Lands Department Lithographs, 1904.

### Granite (G).

No less "out of it," as regards artesian water possibilities, are the granites which lie mainly west and north-west of my route. According to Woodward and Hardman, an extensive area of this rock stretches from near the junction of McPhee Creek with the Denham River south-westward to the head of the Elvire River, (Sheets 141, 132, 133, 131, and 130\*), a distance of over 150 miles. I crossed the prolongation of this belt west of Hall's Creek on the upper waters of the Laura and Margaret (Sheet 130\*). Further patches were traversed along the telegraph line, west of Dead Horse Creek, and from the gorge of the Margaret, between the Mueller and King Leopold Ranges, to Minnie Pool (Sheet 130\*) In the region thus known to me the granite evidently represents the ultimate stage of metamorphism of the sedimentary "Silurian, Cambro-Silurian or Cambrian" rocks.

### Basaltic Rocks (B).

The western edge of what was designated by Hardman "the Great Antrim Plateau," an area consisting essentially of bedded basic lavas, is mapped by him as extending from a point east of Flora Valley Station (Sheet 131\*), north-eastward to Mount Napier in the Northern Territory (Sheet 132\*). He then brings it, with a sweep to the east, north, and west, back to Western Australia north of the Negri River (Sheet 132\*), and after making it include Mount Close and its vicinity, takes it again into the Northern Territory in lat. 16 degrees 45 minutes south (Sheet 132\*), a little north of the northernmost limit of his journey. Travelling, as I did, from north to south, I first came on the basaltic area at "Pickle Bottle" camp, 16 degrees 4 minutes south (Sheet 141\*), and followed it along the border for 47 miles to the point where Hardman places its northern limit.

From a lithological standpoint, the name "basalt" is not sufficiently comprehensive. Hardman describes the assemblage of volcanic rocks as consisting of "many varieties of basalt, including dolerite and anamesite, trachy-dolerites, lavas, volcanic breccias, and ash beds, ferruginous wackonite, etc.," and it is certain that he has by no means exhausted the list.

As regards its age, Hardman says (2nd report, p. 19): "That it is of intermediate age between the Carboniferous and the supposed Devonian rocks is certain, for within a short distance it is found resting on the one, and covered by the rocks of the other formation, as at the junction (and a few miles below it) of the Pantan and Elvire. At J/38 the limestone is also seen resting on the trap rock." (Sheet 132\*).

My own route lay a few miles above (i.e., south of) the junction of the Pantan and Elvire, and here also I found the basalt emerging

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\* Land Department Lithographs, 1904.

from beneath the Carboniferous (?) limestones, and four miles farther west overlying the Devonian sandstones. For nearly 40 miles to the south I saw the Devonian rocks dipping beneath the basalt. The Antrim Plateau, therefore, as far as Hardman saw it, must be approximately on the horizon he ascribes to it. I have, nevertheless, grave doubts whether the almost equally extensive area of basaltic downs (as far as Western Australia is concerned) which I traced from "Pickle Bottle" camp to the right bank of the Negri River is not of much later date. In the latter region, the lava has all the appearance of having simply levelled up a depression formed by the converging Bow and Ord Rivers. If the two basaltic areas are really continuous, I cannot help thinking that there is merely an accidental apposition of two similar masses of widely different ages, the one Devonian and the other probably Tertiary. In what may be called the Argyle area (since the greater part of it is included in the run of that name), the basaltic beds are nearly horizontal and, as far as I can see, overlie the Carboniferous (?) limestone of the Negri Valley. They have covered over the old surface of the Ord River valley with the exception of certain "knife-edge" ridges of Devonian (?) limestone which still protrudes above its level, while other underlying limestone masses (near Argyle Station) have been disclosed by denudation in the bed of the Ord River and its vicinity.

There is some probability that the basalts of this Argyle area were not wholly the result of one continuous period of volcanic activity. Just above what is known as the "Gorge" of the Behn River, between Rosewood Station and Mount Quirk, is a dome or "puy" of basalt, apparently the centre from which issued the lavas that dip away from it to the south-west and north-east. These basalts must have been less fluid than the older beds which form the mass of the Argyle area, since their comparatively rapid solidification has given rise to a thickening in the neighbourhood of the vent and a thinning out as they get farther away, whereas the beds on which they rest appear to have reached, with undiminished fluidity, the limits of the depression into which they were poured.

In a word, I regard the basalts of the Argyle area as probably Tertiary, and as the newest of all the formations represented in the Kimberley district, with the exception of "Pindan" and Recent Alluvium, and possibly the "Upper Tertiary" limestone detected by Hardman on the summit of one of the eminences of the Mount Elder Range.

From the Geological Map accompanying this report, "Alluvium" and "Pindan" have been eliminated. The "Alluvium" is really of very limited area, although Hardman has designated wide regions by the same colour as those "where soils are largely distributed." He had naturally never seen "downs" or the extensive scale on which they are developed from the decomposition of limestones and certain igneous rocks in Australia, and did not realise that they are simply

decomposition products *in situ*. The very large area which he has coloured as "Pindan Gravels and Boulder Beds" marks an instance of the decomposition *in situ* (with the occasional addition of "surface wash") of sandy and gravelly rocks, mainly Upper Carboniferous. "Pindan" it may be explained, is supposed to be an aboriginal word, but is now locally used by the white population to distinguish lightly timbered rolling sandy country. To make "formation" of "pindan" or "downs" merely tends to obscure our conceptions of the actual geological structure.

## Artesian Water Possibilities.

### (1) Wyndham.

The Carboniferous rocks of Wyndham consist principally of dark bluish-grey shales, varying in thickness up to 100 feet. Where these rocks rise into mountain masses, the fact is due to denudation having been arrested by the outcropping of sandstone beds, which are naturally more resistant than the shales. It is usual to refer to the local mountains as "flat-topped" or "sandstone-capped" hills, but the flatness of the strata is only apparent, the rocks, as a matter of fact, generally having a gentle dip. In the immediate vicinity of Wyndham the dip is to the south-east (*e.g.*, in the Bastion Range), although to the eye of an observer placed on the north-west the outcrop of any conspicuous bed appears to be strictly horizontal.

Of the conditions favourable to the existence of artesian matter some of the most important are present at Wyndham.

These are :—

- (1). The occurrence of alternating strata of shale (consolidated clay, to all intents and purposes impermeable) with sandstones (more or less permeable) and
- (2). A dip such as may carry permeable beds from their outcrops in the mountains to not inaccessible depths beneath the places where water is required.

The problem, as regards Wyndham, may be thus formulated. At this port cattle are shipped in large numbers but under conditions of severe hardship. The cattle get no water to drink, as a rule, between the "Twelve-mile" and the steamer. Should any delay occur in shipping, there is nothing for it but to drive the animals back to the water. One instance of a mob having been driven to and from the port for ten consecutive days was related to me.

For the limited human population, rain water and wells, supplemented if necessary, by the distillation of sea water, might suffice, but thousands of cattle cannot thus be provided for.

Something has already been done, or at least attempted, to meet the difficulty, but the experiments have been attended with more expense than success.

Wells have been sunk : (1) behind the Courthouse, (2) behind the Gaol, and (3) in the valley between the West Bastion and Mount Albany.

The court-house well was (on 19th November last) nearly dry. The water was good but the collecting of a bucketful took a long time.

The gaol well (96 feet deep) has a more copious supply (3,000 gallons per day) but the water is too brackish for human consumption, although thirsty horses will drink a little of it. It is said to become distinctly saltier at spring tides. A bore was sunk 594 feet further, but no more water was met with.

From the section given in "Description and Diagrams of Bores for Water and Coal to 30th June, 1900, Public Works Department," it will be seen that shales (sometimes called slates) were almost exclusively met with in the upper half of the bore, while in the lower half "hard grey crystalline sandstone" with slate (shale) bands were the prevailing rocks. In the few fragments of core which I have been able to see the shales are not at all altered, nor are the sandstones extravagantly hard.

The well (Dilyan Springs) in the valley between Mount Bastion and Mount Albany was dry on 16th November. It has been fitted with a windmill which, when there is water, delivers into a service tank at the gaol. The town has also been reticulated with pipes in anticipation of a supply which was not forthcoming.

Two of the conditions upon which artesian water depends may now be discussed, viz. :—(a.) Are there to be found beneath the site of a bore strata which rise to an outcrop on a still more elevated site? and (b.) Are these strata sufficiently open to admit of the passage of water?

- (a.) Assuming a seaside site in Section 82 of the township (selected for reasons afterwards given) and a continuation of the observed rise of the strata (7 deg.) to the north-west, a bore 4,000 feet deep would cut 3,970 feet of strata, among which there is reason to believe some thick beds of sandstone or conglomerate would be met with, such beds rising to their outcrops in the high ground bounded on the east by the west arm of Cambridge Gulf, on the north by the Forrest River, and on the west by the Ernest River.



- (b.) The thick sandstone forming the "cap" of the West Bastion is fairly hard and close-grained, and (the grains of sand having been recemented by dissolved silica) would be described by many, without hesitation, as "quartzite," and the conclusion would be arrived at that it would prove impermeable to water. It is, however, no uncommon experience in tropical countries that sandstones intensely hard and close on the surface prove comparatively soft and open at a depth. As specific instances within my own knowledge may be mentioned the sandstones at Croydon and Montalbyn (Queensland). The marked difference in hardness between the Devonian sandstones of the surface and similar sandstones at the depth of 65 feet observed during my journey in a well near Emu Springs is another case in point. My theory on the subject is that the superficial water, being much warmer than in temperate latitudes, dissolves a great deal of silica which, on redeposition, tends to close up the interstices of the rock, but that this is only a superficial phenomenon.

I was informed by Mr. Cunningham, late postmaster at Wyndham, that the sandstone beds met with in the Gaol bore were in some instances soft enough to be named "sand" by the borers, although the record of the bore makes no mention of such beds. If they actually occurred, the inquiry will be made, "Why, then, did they not carry water?" The explanation may be that these strata crop out under the Gulf, whose muddy bottom prevents their becoming water-conveying channels.

Mr. A. Gibb Maitland, Government Geologist, having travelled extensively in the region west of Wyndham, I felt sure that his observations must have furnished important data on the question of the outcrops of the strata underlying Wyndham. Having been communicated with by telegram, his reply (from Marble Bar, 17th November) was as follows:—

Wyndham beds extend as continuous formation west to mouth of Prince Regent River and from Mt. Hart on Leopold Range north to Admiralty Gulf. Beds have prevailing dip North-West, and comprise quartzite, grits, conglomerates, with interbedded igneous rocks. Am afraid not porous enough.

The south-west dip in the Bastion Range, and the north-west dip observed farther west by Mr. Maitland, point to the existence of an anticlinal arch, which at any rate, must be west of the Ernest River. The south-eastern slope of such an arch would expose, in high country, the outcrops of strata which would pass, and, it may be hoped, carry water, beneath Wyndham.

Mr. H. P. Woodward, then Government Geologist, reporting in 1891 on the "Goldfields of Kimberley District," expressed an

opinion in favour of the prospects of artesian water at Wyndham, although he does not seem to have based his conclusions on any dip of the Carboniferous strata (which, in fact, he refers to as horizontal). His exact words (p. 8) are:—

In the Northern portion of this district (near Wyndham) the rocks are horizontally bedded, the water supply being obtained on the top of, or a little way into, shale beds beneath which the whole subterranean drainage from the interior passes. Therefore, if a bore were put through these beds a large supply would be encountered which would rise to the sea-level, if it did not rise a good height above the surface; in fact this is an artesian area.

In my view, water would rise to the level of the "head of water" (the outcrop of the stratum) or, where the rim of the artesian basin is partly depressed or broken, to the "hydraulic surface," viz., a line drawn from the head of water (intake) to the outlet or leak.

**SITE OF BORE.**—The thick sandstone bed near the summit of Mount Bastion dips, as has been observed, at about 7 degrees to the south-east. As the valley of the West Arm cuts through this stratum obliquely to the strike of the sandstone, the latter is found to the south capping hills at lower elevations. Approximately, its base on the West Bastion is 1,000 feet above sea-level, while at Mount Albany it is only 400 feet.

The gaol well and bore give a section of 690 feet of strata, commencing about 4,000 feet below the horizon of the sandstone. On the site recommended (Section 82 \*) a bore would commence about 1,000 feet below the sandstone, and would thus have 600 feet of an advantage over a bore at the gaol, beginning about 90 feet above where the gaol bore left off.

Even such an apparently small amount as 600 feet may make an important difference when it is considered that 4,000 or 5,000 feet may be taken as the limit of practicable and economical boring.

Mr. Gibb Maitland, in "Report of the Geological Survey for 1902," gives a section of the strata from Mount Albion to the Three-mile. The section of the strata dipping from the former to the latter is pierced, near the Three-mile, by an intrusive mass of basalt, on which he remarks that "any water received on the northern face of the range and percolating down the dips would be checked by this wall of impervious rock, behind which it would tend to accumulate until the water is thrown out by springs." Should such an intrusion of impermeable rock interrupt strata which crop out at high altitudes west of the face of the Range, a situation ideally favourable to artesian water would be created, *unless* similar intrusions to the west should be found to *shut off* the water from the supposed strata.

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\* Section 82 of the surveyed township. The existing buildings are on a much less suitable site.

I am of opinion that, although unforeseen difficulties, such as igneous dykes or close-grained rocks, may lead to failure, *all that is ascertainable* gives strong grounds for hoping that a deep bore would meet with success. A successful artesian bore would be the only adequate solution (short of a pumping scheme) of the stock water difficulty which now so seriously retards the progress of Wyndham.

At the same time it would be worth while, before committing the Government to a large expenditure on what is, after all, a *chance* (although in my opinion a good chance) to estimate the cost of a water supply pumped up from the springs at the Gut and conveyed in pipes to the township. The distance as the crow flies is about seven miles.

### (2.) Country East and North-East of Wyndham.

In the southern portion of this region (Sheet 142\*) the Ord River has, I believe, a permanent supply of water, serviceable as far as stock can feed back from the frontage.

Should artesian water coming from outcrops far to the west be found at Wyndham, it should be found here also but at greater depths, calculable by the distance and the average dip of seven degrees. I should not advise boring here until after an experiment at Wyndham.

The prospects of artesian water being found at shallow depths would depend on water taken in by the outcrops of local eminences to the west, which are, so far as my knowledge extends, too limited in area to furnish any supply of importance.

### (3.) Devonian Region between Wyndham and the Carr-Boyd Ranges.

In this region (Sheets 142 and 141\*) the prevailing rocks are indurated sandstones, frequently approaching the character of quartzites, in beds which are parted by accumulations of shale. My traverse has made me fairly well acquainted with its eastern portion (extending to about 35 miles west of the Northern Territory), but of the western part my knowledge is limited to what has been put on record by Woodward regarding the Saw and Deception Ranges and what I have myself seen of Mount Erskine from the north. Mount Erskine appears to consist of the usual sandstones and shales bent into an anticlinal arch, the strata dipping to north-west and south-east. In the Saw Range, according to Woodward, the dip is to the west, while farther east it is in the opposite direction, so that here also there must be an anticlinal arch. From Goose Hill eastward to the north and south reach of the Ord River opposite Ivanhoe Stud Station the strata dip to the east, or a little to the north of east, at an average of 30 degrees, forming a mass of rugged

\* Lands Department Lithographs, 1904.

hills to the west of the river. These hills rise, I should judge, to about 600 feet above the sea level, on an average, and follow the west or left bank of the river for 20 miles. At one point (H.J.8 on Sheet 142\*) the altitude is given on the map as 958 feet.

The land on the eastern side of the river, except for isolated eminences, is at a much lower level than that on the western, but is evidently formed from similar rocks. I should judge the bulk of it to be not more than 250 feet (the level of Emu Springs). Emu Springs (Sheet 142\*), it may be mentioned, are "well eyes" in a pandanus swamp, and I cannot account for them otherwise than by supposing that the water is brought to the surface by some obstruction such as an igneous dyke concealed by the soil. About  $3\frac{1}{2}$  miles east of the springs I found a party (Torrance and Smith) engaged in sinking a well for the road board. It was down 65 feet, the contract being 85 feet, and no water had, so far, been met with. Although the sinkers called the sandstone "hard," it was soft by comparison with the outcrops of the Devonian beds, and of an open texture favourable enough to the passage or storage of water. The Eight-mile Well,  $5\frac{1}{2}$  miles to the south-east, is sunk 65 feet in sandstone not quite so soft as that of the other. The water is slightly salt but not too much so for drinking purposes. Cockatoo Springs (Sheet 141\*) are similar to Emu Springs, the soil concealing all evidences of the source of the water.

In this region, east of the river (*provided a low site were selected*), I should expect artesian water at no great depth, its source being the elevated outcrops of sandstone extending south from Button's Gap and westward. The only circumstance to cause uneasiness is the supposed hardness of the strata, which seems to be disproved, or at least its probability lessened, by the experience obtained in sinking the wells above referred to.

#### (4.) The "Argyle" Basaltic Area.

This area, or at any rate the Western Australian portion of it (Sheets 141 and 132\*), is fairly well supplied with surface water. The Behn, Ord, and Bow rivers traverse it from south to north, and all, especially the two last-named, have what I believe to be "permanent" water-holes. Again, although I have not seen the locality, there should, if one may judge from the map, be no engineering difficulty in fluming water from the "copious very hot springs" 13 miles west of Lissadell Station to supply a portion of the run. There are, however, portions of considerable extent where grass grows and yet water is too far distant for stock, so that it is possible that artesian water may be among the requirements of the future.

It has already been said that I regard the basalts of this region as having filled up a depression in the neighbourhood of the junction of the Ord and Bow. The surface over which the molten basaltic

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\* Lands Department Lithographs, 1904.

lavas were poured out was, no doubt, composed of Devonian and Silurian, or still older, Metamorphic rocks. The Ord and Bow must have been compelled to cut out new channels for themselves after their valleys had been filled up with basalt.

The attitude of the lower edge of the basalt is a factor of high importance in the calculation of the chances of obtaining artesian water, and it is unfortunate that very few data on this subject are available. Presumably the highest point is about the spot where the road from the Wild Dog Police Station crosses it north of the Negri River, and this point may be assumed, from readings in the vicinity, to be about 650 feet above the sea. Argyle Station, by the same aneroid, is 380 feet, and the river at the northern end of the area will therefore be about 300 feet. These readings would, in the distance of 56 miles separating the two points in question, give a fall of 350 feet, or 1 in 845. Supposing the drainage of the high Silurian (or older) land to the south to flow partly underground between the old surface and its present basaltic covering, or to enter any comparatively porous beds of the volcanic series (such as tuffs or scoriaceous lavas), artesian water would be tapped by a bore in any locality where the surface was lower than the intake. It may be argued that a grade of 1 in 845 is very slight for a flow of water, but evidence is not wanting that in spite of the lowness of the grade water *does* flow in or beneath the basalt. Springs rise to the surface at the police station and at the so-called "Sugar" Springs. The water at both places is apparently brought to the surface by the obstruction put in the way of its northward flow by the limestone barrier standing up above the basalt and forming a portion of the old, hard, pre-basaltic surface. It may here be noted that the "Sugar" Springs, five or six in number, rise out of the basalt east of the limestone. They have recently been opened out by the Public Works Department, and the water led into trenches which ultimately direct it into a creek, with the result that a permanent, if limited, supply for travellers and cattle is assured. An attempt was also made to bore for artesian water, but the hand-drills employed were found to be incapable of piercing the basalt to a greater depth than 40 feet.

It might naturally be supposed that the barrier of pre-basaltic land represented by the Rosewood limestone wall would effectually block the flow of underground water to the north-west. But that the flow is *not* blocked is proved by the occurrence of the Stockade Creek "Soda" Springs. These are similar in character to the "Sugar" Springs, although on a larger scale, and make a waterhole nearly a quarter of a mile in length. Nothing is seen to account for the water rising to the surface, but it may be assumed that a barrier of some hard pre-basaltic rock, such as is visible beside the "Sugar" Springs, exists beneath the soil. Limestone, in fact, is seen on the track between the Springs and Argyle Station, not

very far from the Springs. That the underground flow of water is not stopped by the Rosewood "wall," shows that the wall, although coloured on the map (from information supplied) as continuous, must be breached in one or more places—must, in fact, have been cut through by the Ord or its tributaries prior to the out-pouring of the basalt.

Reviewing the whole of the evidence, I am inclined to believe that artesian water may be obtained in any part of the Argyle basaltic area where the surface is not higher than the intake. In view of the insufficient *data* existing regarding altitudes in this region, I should, however, recommend that, before the expense of boring is incurred, levels should be taken between any proposed bore site and some definite and fairly high portion of the "intake," such as the point where the road from the police station to Texas (Kelly's Station) crosses the southern limit of the basalt north of the Negri. The hardness of the basalt must be taken into account in estimating the cost of boring, but I believe that the basalt is of no great thickness—probably less than 300 feet—except in places such as Mount Quirk, Mount Evelyn, Mount Close, and the hills between the 14-mile Creek and Spring Creek.

#### (5.) The Great Antrim Basaltic Plateau.

From the relative altitudes of the eminence J 32 on the top of the plateau (1,661 feet) and the junction of the base of the basalt with the top of the Devonian formation near the Camel Creek Yard (about 1,000 feet), the total thickness of the basaltic beds may be taken to be at least 660 feet. Hardman's estimate (Second Report, p. 18) is 1,126 feet, and it is probable that, as a maximum, this is within the mark. But in questions of boring it is not the maximum thickness deposited, but the minimum to which the formation has been denuded that has to be taken into account. Should the "dip" of the basaltic beds, as seen on the eastern edge of the plateau (about 20 degrees), persist for any distance to the east, the thickness of the basalt would soon be enormously increased, but there is reason to believe that the dip flattens to the east, and, according to Hardman's observations, the beds must swing round to dip beneath the Carboniferous(?) limestone of the Nicholson Valley.

The line along which the Devonian sandstones dip beneath the basalts of the plateau has an approximate elevation above sea-level of from 1,200 feet opposite Flora Valley Station to 800 feet near the junction of the Panton and Elvire Rivers.

The grits and sandstones of the Devonian formation of the Albert Edward Range, dipping to the east and traversed along their strike by the Elvire River, are (unless they are too close-grained, which is more than doubtful) disposed in the most favourable manner conceivable for carrying water beneath the basaltic plateau. The sedimentary Devonian rocks in the west of the Albert Edward

Range, where they abut on the older metamorphic rocks, dip to the east, or south-east, at high angles, but the dip diminishes to the east until, at its junction with the basalt it is not more than 20 degrees, the basalt itself dipping at the same angle. If the basalts are interbedded with the Devonian rocks, or succeeded them, so to speak, "conformably," and if we accept Hardman's view that the basalts turn round and dip to the north-west, the Devonian rocks must, not many miles east of the Elvire, flatten out and form a basin beneath the plateau.

No condition more favourable to the existence of artesian water could be imagined, but it must be admitted that there is a good deal of the theoretical about it. I should not advise boring on the plateau until a mass of information, still wanting, has been accumulated with the object of throwing light on the dip and thickness of the basalt. A good many lines might be run from the Elvire across the plateau, and accurately levelled for less than the cost of a single unsuccessful deep bore in hard country.

At the same time anyone who is inclined to "chance it," in a sporting spirit, may have the luck to hit upon comparatively shallow artesian water (probably very limited in amount) derived from the outcrop of some elevated porous volcanic bed within the area of the plateau itself. Personally I should much prefer the compilation of reliable data, followed by logical reasoning.

#### **(6.) The Carboniferous (?) Limestone Area between the Junction of the Negri and Ord Rivers and the head of the Turner.**

This formation (Sheet 132\*), in which beds of limestone predominate over the sandstone and shale beds, and give rise to extensive "downs" (mapped by Hardman as "Recent"), is seen overlying the basalt between the Hardman Range, and the Elvire River, and, according to Hardman, it bears the same relation to the basalt of the Great Antrim Plateau north-east of the head of the Turner. Its basal beds must, therefore, have an elevation of between 1,000 and 1,200 feet. The greater part of the extensive "downs" between the plateau and the Ord River does not rise above 600 to 800 feet. The strata, which at the south-western and south-eastern boundary of the formation dip to the north-east and north-west, are practically horizontal on the Ord River below its junction with the Elvire, and probably continue to be horizontal where they are covered, on the left bank of the Ord, by the upper or sandstone member of the Carboniferous series until they are faulted against the metamorphic rocks north-west of the Dixon Range. Such a disposition of the strata, supposing some of them to be sufficiently porous, is favourable to the occurrence of artesian water, and become artesian on being released by bores. The success of boring operations will

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\* Lands Department Lithographs, 1904.



depend (1) upon whether or not porous beds occur near the base of the formation, and (2) whether there are water-bearing channels in the limestone itself. As regards the first, all that I can say is that between the Hardman Range and the Elvire River the basal beds are limestone and not sandstone. On the other hand, there are flaggy sandstones in the "downs" between Forrest creek and the Ord River, and there may very well be thick and porous beds in the formation which did not come under my eye. In the alternative case, it is well known that almost every extensive limestone deposit is channelled with underground watercourses. To strike one of these in a bore is, of course, purely a matter of luck.

Failing artesian water in the formation itself, there is a chance of finding it by penetrating the underlying basalts and reaching the Devonian sandstones. To this course it is more than likely that the thickness of the basalts, added to that of the limestone formation itself, will form an insuperable obstacle. At all events it would be well to await definite information as to the thickness of the basalt before making the experiment.

#### **(7.) The Carboniferous Sandstone Area between Glass Hill and the Dixon Range.**

This formation (Sheet 132\*) overlies the Carboniferous (?) limestone, and is extensively developed on the north-western side of the Ord; the Mount Elder Range, on the opposite side, being an outlier of less extent. The prevailing strata consist of white sandstone in horizontal beds, giving rise to tablelands (often denuded to mere fragments) bounded by steep escarpments three or four hundred feet in height. Intervening between these tablelands are extensive sandy "downs" resulting from the degradation of the sandstone. A large area of these "well-grassed plains" has been mapped by Hardman as "Recent."

Naturally no one would dream of boring for artesian water on the fragmentary tablelands; such operations, if attempted, would be confined to the "downs." In the event of the latter being pierced by a bore, the Carboniferous (?) limestone formation would certainly be met with in a few hundreds of feet at the utmost, and the problem before the borer would be precisely the same as that confronting a borer in the limestone formation. (*See previous section No. 6.*)

#### **(8.) Flora Valley Carboniferous Sandstone Area.**

It is probable that in the low country, anywhere between Gullana Hill and Mount Timperley, artesian water may be met with at no great depth, either in the Carboniferous sandstone itself or in the underlying Devonian rocks.

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\* Lands Department Lithographs, 1904.

**(9.) The Carboniferous (?) Limestone Area between the Rough and Barker Ranges.**

This large area, trending from south-east to north-west includes the Rough, Hull, Geikie, and Napier Ranges, and a portion of the Oscar Range (Sheets 130, 129, and 134\*). The formation is composed, so far as my observations went, almost exclusively of limestone, with partings of shale. The strata dip to the south-west, at steep angles, away from the granite of the Lower Louisa Valley and the slaty and schistose metamorphic rocks of the ranges to the north-west upon which they rest unconformably. On reaching the plains, the dip becomes less and less steep, and the strata pass beneath the Carboniferous sandstone series.

The country is fairly well supplied with surface water except, perhaps, at the south-eastern extremity, where it attains a breadth of 30 miles, and even there the Fitzroy and Margaret Rivers provide long well-watered frontages. Back from the frontages, however, prolonged droughts such as the one that had barely come to an end when I passed through, give rise to heartrending distress.

I can only repeat what has been already said in dealing with the Limestone Area between the junction of the Negri and Ord Rivers and the head of the Turner (Section 6), that the success of bores in limestone country is a matter of luck, depending on the chances of striking a subterranean water-bearing channel. One such channel, it may be pointed out, is known in the district now under consideration. Near the north-west end of the Oscar Range a creek disappears underground, and has been followed by my informant until it re-emerges half a mile lower. It is certain that, either in such channels or between the limestone and the underlying metamorphic rocks, there must be enormous quantities of water, derived from the drainage of the south-western slope of the Metamorphic ranges. Several springs arise in the limestone near Oscar Range Station.

**(10.) The Carboniferous Sandstone Area south-west of the Oscar and Napier Ranges.**

This area is mainly drained by the Fitzroy and Lennard Rivers. Partly from my own traverse on the way to Derby and partly from Hardman's mapping (the "Pindan" foundation being eliminated), I have coloured with confidence, as included in it, over 12,000 square miles. The whole of this enormous area, with the exception of a number of tablelands, there is good reason to believe, is capable of furnishing artesian water.

The strata, chiefly sandstone and shales, dip to the south-west, where they succeed the limestone on the flanks of the Rough, the Oscar, and the Napier Ranges. In passing to the south-west, however, they soon become to all intents and purposes horizontal.

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\* Lands Department Lithographs, 1904.

and are thus, provided the basal beds of the formation crop out at sufficiently high altitudes, favourably disposed to the existence of artesian water. There is little doubt that the outcrop of the basal bed is high enough. From opposite the Fitzroy telegraph station to opposite the north-west end of the Oscar Range, the elevation of the junction line between sandstone and limestone varies from 500 to 600 feet above sea level, while (except for the tablelands) the general level of the district under consideration can seldom rise above 300 feet.

From Derby to the Fitzroy telegraph station, travellers usually take the circuitous road up the right bank of the Fitzroy, rather than that by the telegraph line, which is nearly direct. On the latter road, there is, in ordinary seasons, a dry stage from the 40 mile to the 92-mile post. When I was travelling in the reverse direction, I was able to follow the telegraph line most of the way, a recent fall of rain having put water in the 57-mile Creek and reduced the dry stage of 52-mile to two stages of 25 and 27 miles. Between the two roads, and south of the Fitzroy, there are broad tracts of country, far removed from water frontages, where abundant grass is useless to stock because of the want of water. In such localities, there is no doubt that artesian water would be of great value, and would immensely increase the cattle-carrying capacity of the pastoral holdings.

It may be well, at this stage, to record such information as has been collected with reference to springs and wells in this region.

### Springs.

Probably the most important of all is the spring south-east of Mount Wynne (Sheet 129\*), which has an estimated flow of 250,000 gallons per 24 hours.

About six miles south-east of the Lower Liverynga, a mud spring is met with. About two miles farther south, five springs break out on a line running north-west and south-east. These springs discharge not only sand but also fishes, which are said to be sightless. A pipe having been driven into one of the springs, the water rose  $3\frac{1}{2}$  feet above the ground.

Eudyella Springs are on the left bank of the Fitzroy, south of Lower Liverynga Station. (Sheet 135\*).

Some springs, about nine miles south-west of the station, give out a stream strong enough to "run" Margaret Creek for six miles.

There are also springs of some importance about 15 miles south of Upper Liverynga, between the Fitzroy River and Mount Arthur. (Sheet 128\*)

The above information is given on the authority of Mr. Percival Rose, general manager for the Kimberley Pastoral Company.

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\* Lands Department Lithographs, 1904.

### Wells.

On account of the long dry stage on the telegraph line which has already been referred to, travellers from east to west have to leave the line at Limestone Creek (92 miles from Derby) and make for the site of the old police station on the Lennard—a distance of 30 miles between water and water. A Government well, east of Mount North and north of Mount Percy, breaks up the 30 mile stage into stages of 18 and 12 miles. Beyond the fact that the well has water in it, I was unable to learn any particulars. (Sheet 134\*).

A well, 60 feet in depth, at the Lennard Station has "a little" fresh water.

A shaft was sunk on the telegraph line, at 71 miles 26 chains, to a depth of 100 feet, without meeting any water. So far as I could see the shaft (which had partly fallen in), there was dark carbonaceous shale beneath ten feet of cemented gravel (Hardman's "pindan" formation).

Two series of wells have been made on Balmaningarra run and for the information regarding these I am indebted to Mr. J. L. Hutton, the manager. The approximate position of the wells is given on Sheets 134 and 135\*.

The first series was sunk by Wilson and Buck.

No. 1 well (Sheet 145\*) on Mr. M. C. Davies' Block 330/98, 16 miles east of Derby, is  $102\frac{1}{2}$  feet deep, and has eight feet of water. The last rock turned up by the sinkers, as I saw it in passing, was a very soft, crumbling white grit, well fitted for the retention or passage of water.

Wells Nos. 2 and 4 (Sheet 134\*) are about four miles south of the telegraph line, No. 2 south of the 45, and No. 4 south of the 55-mile post, and No. 3 is in an intermediate position.

No. 2,  $39\frac{1}{2}$  feet deep, with 13 feet 3 inches of water.

No. 3, 61 feet deep. Water in bore at  $36\frac{1}{2}$  feet.

No. 4, 60 feet 10 inches deep. Water struck in bore at 53 feet, rose to 45 feet 10 inches.

The second series was sunk by Foley and Hillier (Sheet 134\*).

Nos. 1 and 2, on the dividing line between Blocks 248/98 and 249/98, were both  $15\frac{1}{2}$  feet in depth, and met with salt water. A report by the Government Analyst gives the proportion of sodium chloride as 1580 grains per gallon in No. 1 and  $577\frac{1}{2}$  grains in No. 2.

No. 3 well, about three miles east of No. 2, struck comparatively fresh water at 35 feet. It stands 19 feet deep, and, according to analysis, has  $288\frac{1}{2}$  grains of sodium chloride per gallon.

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\* Lands Department Lithographs, 1904.

No. 4, about a mile west of the station, is  $28\frac{1}{2}$  feet deep and has 66 feet of fresh water. The analysis gives only 79.3 grains of lime chloride per gallon.

No. 5, three miles north-east of station, has a depth of 42 feet. Fresh water was met with at 28 feet and rose 12 inches.

### Upper Liverynga Bores.

Two bores on this run, as I am informed by Mr. Rose, have actually struck artesian water at shallow depths.

One, about three miles north-east of Mount Wynne, has a flow of 7,000 gallons per 24 hours. I could not ascertain the precise depth of the bore (Sheet 134\*).

The other, about three miles north-east of the station (Sheet 135\*), is 70 feet deep, and discharges 1,500 gallons per 24 hours. A  $1\frac{1}{2}$ -in. pipe having been cemented in, the water rises 12 inches above the surface.

### Yeeda Wells.

The information regarding these wells is given on the authority of Mr. T. Galbraith, the manager. Their position (east of the Yeeda River) is marked on Sheet 135\*.

No. 1, 40 feet deep; in sandstone; seven feet of water.

No. 2, 35 feet deep; in sandstone; seven feet of water, which rises from a hole in bottom, and *pulsates*.

No. 3, 28 feet deep; in sandstone and ironstone; five feet of water.

No. 4, 80 feet deep; in sandstone; eight feet of water; supply large to be baled out.

No. 5, 95 feet deep; in sandstone; 20 feet of water.

No. 6, in progress.

### Wells between Meda Station and Derby.

A well was sunk by the Road Board, about  $1\frac{1}{2}$  miles west of Meda and Buck's No. 1 well, to a depth of 70 feet, without success. (Sheet 135\*).

At Gooda Gooda, on the edge of the swamp, about seven miles west of Derby, a well (Sheet 135\*), just above high water mark, has a copious supply of fresh water at a depth of about 12 feet.

Mayalli Well, about three miles south-east of Derby, is 30 feet deep, and has about six feet of somewhat brackish "stock" water. It has a windmill and a hot air pump, a tank of a capacity of 25,000 gallons, and troughing. As regards the supply, I was informed

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\* Lands Department Lithographs, 1904.

that it has watered 1,000 head of cattle continuously for a week. Reckoning 10 gallons of water per head daily, this would amount in a week to 70,000 gallons.

### Wells in Derby.

These wells, which are too close together to be shown on the 300 chain map, are located on the six chain plan of the "Townsite of Derby," 1896.

The Town and Jetty Supply Well is in the north-west corner of the Hamersley Square. I visited it and obtained from Mr. Armistage, of the Water Supply Department, the following particulars:—

The water is pumped by a windmill to elevated tanks and delivered by pipes to the town and jetty. A gas engine is about to be installed, and a new reticulation has been commenced. A shaft was first sunk to the depth of 35 feet, the section showing three feet of sand, four feet of gravel, and 28 feet of "rock." Water was struck in "pipe-clay" (decomposed shale), in a bore which was carried down to 50 feet. The water rose in the bore, which, however, was plugged up, and the shaft was sunk to a total depth of 48 feet. The water then rose to 20 feet from the surface, a level which it has since maintained.

The supply has, at times, not been equal to the demand, but this is attributed not to the well but to the windmill.

The private wells in the town were gauged during my stay in Derby, with the guidance and assistance of Mr. McGovern, one of the oldest and most enterprising residents.

*In Allotment 42.*—Well 26 ft. 8 ins. deep. Bored to 52 ft. 8 ins. through "pipe-clay" to water-bearing bed, when the water rose in an hour to 15 feet from surface. Water now standing 15 ft. 3 ins. from surface.

*In Allotment 43.*—Depth 31 feet; 16 feet 3 inches of water standing.

*In Allotment 84.*—Depth, 21 feet 4 inches. Water now standing 18½ feet from surface.

*In Allotment 45.*—Depth, 31 feet 9 inches. Water now standing 14 feet 4 inches from surface.

*In Allotment 76.*—Depth, 32 feet 4 inches. Water now standing 17 feet 3 inches from surface.

*In Chinese Garden.*—(Allotment 72) (?).—Depth, 39 feet 9 inches. Water now standing 25 feet 1 inch from surface.

*In Forrest Street, opposite Allotment No. 1.—Shallow ; surface soak only.*

*In Delaware Street, opposite Allotment No. 54 :—Shallow ; surface soak only.*

### **Observations on Wells and Bores in Area 9.**

The sub-artesian character of a large number of the wells is very significant. That water, when met with in a well or bore, should rise for some distance, even if it comes short of the surface, proves that the water is conveyed in a stratum of rock which rises to the surface at an altitude at least as high as that to which it rises in the well or bore when the impervious bed overlying it has been pierced.

*The sub-artesian water would have been artesian water if the surface had been lower.* If we take, for instance, a site 100 feet above sea-level, and, on boring to 50 feet, strike water which rises to 40 feet, or to 90 feet above sea-level, we have missed artesian water by only ten feet. In other words, if the surface had been 90 feet or say 89 feet, above sea-level, we should have had an artesian supply. This shows the necessity of *selecting low sites* for bores, except, of course, in areas where the underground water-level is already well known. In the hypothetical case we have used as an illustration, the water-bearing stratum must rise to the surface at a higher level than the surface of the bore, but had the bore been carried deeper into the same formation, it is highly probable that further water-bearing strata rising to more distant and more elevated outcrops would have been met with, triumphantly realising the desired object, viz. : artesian water.

It cannot be too strongly insisted upon that two artesian bores (at Liverynga) have already been sunk in the district. Although these bores are on a small scale, they, and numerous sub-artesian wells and bores, prove that artesian water is no longer a matter of theory.

The delay of my steamer for a few hours at Broome enabled me to visit, with Mr. Armitage, the town and jetty supply wells in that township. They are situated near the English Church, at the foot of a ridge of blown sand, and about 44 feet above sea-level.

The three wells from which the supply is pumped for the town and jetty are all between 10 and 11 feet in depth, and yield a copious supply of fresh water. One of them, however, was sunk a foot farther and got into salt water.

In the same enclosure, a bore is in progress in search of artesian water. The following notes on samples of strata from various depths may be of interest, as showing the nature of the rocks met with



in nearly 500 feet of boring through Carboniferous rocks—the same formation as that at Derby (Area 9):—

Fine red sand, from surface to ... ..	30 feet
Red sandstone, thence to ... ..	46 "
Fine white argillaceous and siliceous sandstone, thence to ... ..	68 "
Fine siliceous sandstone, purely coherent, thence to ... ..	80 "
Fine siliceous sandstone, thence to ... ..	88 "
Fine siliceous sandstone, less coherent, thence to ... ..	103 "
Fine siliceous sand with mica, thence to ... ..	210 "
Unconsolidated siliceous grit (grains size of No. 1 shot), with salt water, thence to ... ..	220 "
Fine white siliceous sand (core), thence to ... ..	282 "
Fine red siliceous sand, thence to ... ..	290 "
Coarse, friable siliceous, felspathic grit (grains size of swan shot) with salt water, thence to ... ..	310 "
Fine white siliceous sand (core), thence to ... ..	340 "
Unconsolidated siliceous grit (grains size of No. 1 shot) with salt water (core), thence to ... ..	345 "
Fine white siliceous and micaceous sand (core), thence to ... ..	388 "
Fine yellow siliceous grit, thence to ... ..	445 "
Fine siliceous sand, thence to ... ..	451 "
Grey sandstone, thence to ... ..	466 "
Coarse grit or fine conglomerate, with salt water, thence to ... ..	468 "
Coarse siliceous grit, thence to ... ..	478 "

Salt water was standing at 20 feet from the surface.

A record of the strata passed through in the bore at Pelican Hill, Carnarvon, will be found in the Annual Reports of the Geological Survey for the years 1902 and 1903. The bore was carried to a depth of 3,011 feet. The result is thus summed up by Mr. Gibb Maitland:—"At a depth of 2,611 feet the supply of artesian water yielded 300,000 gallons per diem, and at 3,011 feet the supply was 520,000 gallons." When it is remembered that the strata at Carnarvon are Carboniferous, that is, of the same age as those of Derby, there is the less reason to fear that the latter will prove too hard or too close in grain to carry water. As the strata in the Derby district, so far as the evidence goes, present the remaining conditions necessary to the presence of artesian water, there need be no hesitation in making the experiment.

### Concluding Remarks.

My special thanks are due to Mr. Armitage, of the Water Supply Department, for much valuable information; to Dr. Maloney, Resident Magistrate, Wyndham, and Dr. MacQueen, Resident Magistrate, Derby, for placing many facilities at my disposal; to Mr. W. E. Cooke, Government Astronomer, for a careful reduction of my aneroid readings; and to Mr. J. J. Butler, of Wyndham, who supplied horses and saw me successfully through the many difficulties placed in the way by a drought of unprecedented severity.

In the matter of aneroid altitudes, it may be said that the aneroid I carried appears to have, as a rule, given too high results. For example, my reading at Hall's Creek was 1,400 feet, whereas the

correct altitude is more likely to be 1,225 feet, the average of numerous barometrical readings. In spite of this, however, my readings (allowing for atmospheric disturbances) are at least approximately proportional, so that, in speaking of the comparative altitudes of different localities, the validity of the argument is not affected by the error.

In the preceding pages the geological sketch may be tedious to many readers, but it was necessary to show the grounds on which I arrived at my conclusions. The subject has by no means been exhausted, although its further discussion had better, perhaps, be reserved for the pages of a geological journal.

In the latter part of the report I have passed in review nine distinct areas (defined on the map) in which, according to my lights, I anticipate more or less success in the search for artesian water, and have discussed each of them on its own merits. However the financial questions involved may be adjusted between the Government and the pastoral lessees, I entertain no doubt that artesian water is destined to play an important part in the future of the pastoral industry of the Kimberley District.

R. LOGAN JACK.

Surrey Chambers, Perth, 27th February, 1906.

## APPENDIX.

## Itinerary and Notes on Water.

	Sheet of 300 ch. Map.*	Miles.	Notes.
Wyndham to Parry's Lagoon ...	142	15	Permanent water.
Parry's Lagoon to Pear Tree Camp	"	15½	
Pear Tree to "Bend of Ord River" (House Roof Crossing)	"	2½	Permanent water above crossing.
Pear Tree to Ivanhoe Stud Station	"	17	Well.
Ivanhoe to Emu Springs ...	"	18	Permanency of water doubtful.
Emu Springs to Torrance & Smith's Well	"	3½	In progress; no water yet at 65ft.
Torrance and Smith's to 8-Mile Well	"	5½	
8-Mile Well to Cockatoo Springs ...	141	8	Permanent water.
Cockatoo Springs to Golden Gate...	"	3	Waterholes were nearly dry, but replenished by recent rain.
Golden Gate to Pickle Bottle Creek	"	8	Permanency of water doubtful.
Pickle Bottle Creek to Hicks' Creek	"	11	Dry.
Hicks' Creek to Argyle Downs Station	"	11	
(Argyle Downs to Stockade Creek, Soda Springs and back, 10 miles)	...	...	Permanent water.
Argyle Downs to Behn River, last crossing	"	25	Permanent water.
(Behn River to Rosewood Downs Station, Northern Territory, and back, 20 miles)	...	...	Well and water in Stockade Creek.
Behn River to Sugar Springs (bores)	"	4	Permanent water.
Sugar Springs to Argyle Police Station (locally "Wild Dog")	"	12	Permanent water.
Argyle Police Station to Spring Creek (near Spring Vale Station)	"	6	Permanency of water doubtful.
Spring Creek to 14-Mile Creek ...	"	7	Permanent water.
14-Mile Creek to 9-Mile Creek ...	"	7	Water from recent rain.
9-Mile Creek to Negri River ...	132	9	Permanent water.
Negri River to Ord River, Camp 12	"	5	Permanent water.
(Camp 12 to Texas Station, 2 miles; well to Salt Springs in Ord River, 2 miles and back—8 miles)	...	...	Permanent water.
Camp 12 to White Mountain Creek	"	14	Water doubtful.
White Mountain Creek to Kelly's Creek	"	3	Water from recent rain.
Kelly's Creek to Ord River Station (Forrest Creek)	132	7	Wells.
Ord River Station to Gully ...	"	8	Water from recent rain.
Gully to "The Brook," tributary of Linacres River	"	7	Permanent water.

\* Lands Department Lithographs, 1904.

ITINERARY AND NOTES ON WATER—*continued.*

	Sheet of 300 ch. Map.*	Miles.	Notes.
"The Brook" to Nicholson River, first crossing	142	6	Dry.
First to second crossing of Nicholson	"	5	Dry.
Second crossing to Nicholson hut ...	"	6	Permanent water.
Nicholson hut to last crossing of Nicholson	"	5	Permanent water.
Nicholson River to Gap in Hardman Range	"	15	
Hardman Range to Turner River	"	2	Permanent water for digging.
Down Turner River to Crossing ...	"	1½	
Turner River to Gap in Basalt Range	"	4½	
Gap to Springs ... ..	"	2	Permanent water (?)
Springs to Coogeebrin ruined sta- tion, Elvire River	"	6	Permanent water.
Coogeebrin to Camel Creek Yard ...	"	8	Permanency of water doubtful.
Camel Creek Yard to Camp 18 ...	131	7	Dry.
Camp 18 to J 48, Elvire River ...	"	8	Permanent water.
J 48 to Flora Valley Station, Elvire River	"	18	Wells.
Flora Valley to Mud Springs ...	"	15	Permanent water.
Mud Springs to Palm Springs, near Black Elvire River	"	3	Permanent water.
Palm Springs to Hall's Creek Tele- graph Station	"	20	Wells.
Telegraph Station to Head of Hall's Creek, Camp 22	130	5	No permanent water.
Camp 22 to Rockhole Pool (Langley's Sheep Station)	"	12	Permanent water.
Rockhole Pool to Claypan ... ..	"	10	Water from recent rain.
Claypan to Tailers' Camp ... ..	"	2	Water from recent rain.
Tailers' Camp to Laura Billabong	"	4	Water from recent rain.
Laura Billabong to Claypans at 267-mile Telegraph Pole	"	12	Water from recent rain.
Claypans to Margaret River ... ..	"	7	Dry; water from recent rain.
Margaret River to Soda Springs ...	"	12	No water—Water in bed of creek (dig) about 251½ telegraph mileage.
Soda Springs to Gully, between 245 and 250 miles	"	5	Dry.
Gully to Dead Horse Creek, at 240 miles	"	8	Water for digging.
Dead Horse Creek to Spinifex Flat— Camp No. 27, near 233 Telegraph Mile Pole	"	9	Dry.
Camp 27 to Margaret River ... ..	"	15	Nearly dry—water for digging

\* Lands Department Lithographs, 1904.

ITINERARY AND NOTES ON WATER—*continued.*

	Sheet of 300 ch. Map.*	Miles.	Notes.
Margaret River to Spring Creek ...	130	2	Water from recent rains.
Spring Creek to Camp 28 ...	"	1	Dry.
Camp 28 to Pont's Creek ("F 140" Creek)	"	2	Water up creek.
Pont's Creek to Morgan's Grave ... (Res. 1580)	"	15	Water.
Morgan's Grave to Mount Fairbairn	"	2	
Mount Fairbairn to Camp 29, near Telegraph Pole 198 mile	"	2	Dry.
Camp 29 to Rockhole on Louisa River	"	8	Dig for water in sand.
Rockhole to Louisa Crossing ...	"	1½	
Louisa Crossing to Camp 30 on Margaret River, near Black Rock	"	7½	Permanent water in river.
Camp 30 to Minnie Pool ...	"	6	Permanent water.
Minnie Pool to Camp 31 on Margaret River, near Mt. Pierre	129	12	Permanent water.
Camp 31 to McDonald's Crossing of Margaret River	"	8	Permanent water.
McDonald's Crossing to Fitzroy Telegraph Station	"	14	Well.
Fitzroy Telegraph Station to Fitzroy Crossing	"	6	Permanent water.
Fitzroy Crossing to Brooking Creek Hotel	"	1	Permanent water.
Hotel to Oscar Range Station ...	134	14	Permanent water.
Oscar Range Station to "6-mile Well"	"	8	Water.
"6-mile Well" to "120-mile Creek"	"	5	Permanent water.
120-mile Creek to 117-mile Pool ...	"	3	Water from recent rain.
117-mile Pool to 107-mile Creek ...	"	10	Running water—recent rain
107-mile Creek to 100-mile Fence...	"	7	Pool from recent rain.
100-mile Fence to Limestone Creek	"	8	Water scarce; said to be four or five more miles up creek.
Limestone Creek (92-mile) to 67-mile Creek	"	25	Running water from recent rain, but usually dry. Tanks erected for telegraph repairs.

NOTE.—There is usually no water between Limestone Creek and the "Corner Billahong" (May River). Travellers in ordinary weather must leave the telegraph line at Limestone Creek, and go via Mt. Perry and Mt. North (Government Well between) the Lennard River, and Balmaningarra Station, rejoining the telegraph line about the 36 mile pole. Distance, approx. 72 miles.

\* Lands Department Lithographs, 1904.

ITINERARY AND NOTES ON WATER—*continued.*

	Sheet of 300 ch. Map.*	Miles.	Notes.
67-mile Creek to 56-mile Pole ...	"	11	Water from recent rain.
56-mile Pole, North, across Plain (no track) to Creek outside of Bal- maningarra Sheep Paddock	"	6	Permanent water.
Creek to Balmaningarra Station ...	"	8	Permanent water.
Balmaningarra Station to Yard on May River	"	4	Running from recent rain.
Yard to "Corner Billabong" ...	135	5	Permanent water.
"Corner Billabong" to 36-mile Tele- graph Pole	"	8	Water from recent rain.
36-mile Pole to Emanuel's Yard ...	"	3	
Yard to Meda Station ... ..	"	9	Permanent water.
Meda to Open Well ... ..	"	10	
Well to Gooda Gooda ... ..	"	10	Well.
Gooda Gooda to Derby ... ..	"	7	Wells.
		714	

\* Lands Department Lithographs, 1904.





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1907.  
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WESTERN AUSTRALIA.

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# GEOLOGICAL SURVEY.

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BULLETIN No. 26.

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## MISCELLANEOUS REPORTS, Nos. 1—8.

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*Issued under the authority of the Hon. H. Gregory, M.L.A.,  
Minister for Mines.*

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WITH 6 GEOLOGICAL MAPS AND 14 FIGURES.

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PERTH:  
BY AUTHORITY: FRED. WM. SIMPSON, GOVERNMENT PRINTER.

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1907.



## PREFATORY NOTE.

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This Bulletin includes a series of miscellaneous reports by various members of the staff, which in themselves are not sufficiently large to warrant issue as separate publications.

These reports have not been published in the official records of the State (though most of them appeared in the local press) and the issue of them in a collective form will, it is hoped, serve to make known the varied mineral and allied resources of Western Australia.

A. GIBB MAITLAND,  
Government Geologist.

Geological Survey Office,  
Perth, 18th March, 1907.



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# 1.—Possibility of the Occurrence of Artesian Water in the Northampton and Geraldine Districts.

(With a Map.)

The consideration of the question as to whether the pastoral lands lying "beyond Geraldton, North of Northampton" are capable of yielding artesian water is very much a matter of geological investigation and mapping.

It is not clear to what special portion of the Murchison District the motion brought forward in Parliament, on the 6th of December last, refers. This motion reads :—

Whether in view of the fact that the carrying capacity of the great wool-producing centre beyond Geraldine, north of Northampton, would be very much increased if there was an ample and certain water supply, the Government would be prepared at an early date to bore in that district for the purpose of testing whether artesian water existed there or not.

In the year 1897 a traverse was made of the country between Northampton and Peak Hill (*a*), and an examination, in more or less detail, was made of the valley of the Murchison River as far as the big bend at Bompas Hill. Later on, in the year 1900, I traversed the country between Cue and Carnarvon, in connection with the question of artesian water (*b*), and in the early part of 1901 returned from Carnarvon to Northampton along the telegraph line.

These traverses, coupled with the information contained in the different official reports by my predecessors, together with the records of the bores put down during the last few years, afford ample data for dealing with the broader aspects of the question without a special visit to the district being necessary.

Since the date of my report of December 17th, 1896 (*c*), some boring has been carried out in the Champion Bay District, having the search for artesian water for its object. Two of these bores, viz., Dongara (*d*) and Yardarino (*e*), have been successful in obtaining overflowing supplies; the Geraldton Racecourse Bore (*f*), a sub-artesian supply, whilst the Geraldton Station Yard Bore (*g*), having reached bedrock at 420ft., obtained no water.

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(*a*) Annual Progress Report of the Geological Survey for the year, 1897.

Perth: By Authority, 1898, pp. 14-19.

(*b*) Annual Progress Report of the Geological Survey for the year 1900.

Perth: By Authority, 1901, pp. 26-28.

(*c*) Annual Progress Report of the Geological Survey for the year 1896. *Vide* Annual Report Department of Mines for the year 1896. Perth: By Authority, 1897, p. 28.

(*d*) The Mineral Wealth of Western Australia. Geological Survey Bulletin No. 4. Perth: By Authority, 1900, pp. 105-106.

(*e*) Annual Progress Report of the Geological Survey for the year 1901. Perth: By Authority, 1902, pp. 13-14.

(*f*) The Mineral Wealth of Western Australia. Geological Survey Bulletin No. 4. Perth: By Authority, 1900, pp. 140-141.

(*g*) Loc. Cit. p. 139.

The bore at Pelican Hill (a), Carnarvon, which had been carried down to a depth of 3,011ft., obtained an overflowing supply of water at the rate of 520,000 gallons per diem. The record of this bore shows in descending order :—About 150ft. of newer or post-tertiary strata; about 1,211ft. of mesozoic (and possibly cretaceous) rocks; and about 1,650ft. of carboniferous rocks; the base of the latter formation, however, was not reached.

The important point in this bore is the fact that the main artesian supply is drawn from the bed of sandstone, 448ft. in thickness, which forms the lowest bed of the carboniferous series penetrated.

These strata cross the Gascoyne River and extend without any interruption southwards to the valley of the Wooramel somewhere between Innouendy and Bilung Pools (b). At the former place granitic rocks prevail, whilst in the vicinity of the latter, sandstones, shales, and conglomerates, dipping south-west at a low angle, occupy the country. The pebbles in the conglomerate are of rocks identical with those which form the Coor-de-Wandy, Yalbra, and similar hills.

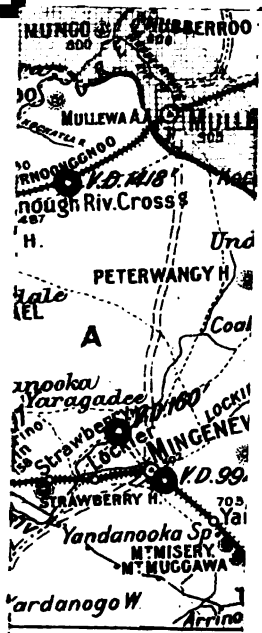
Near the mouth of the Wooramel River there are, in addition to the coastal limestone, fossiliferous tertiary rocks, and the mesozoic beds, from beneath which the carboniferous strata, described in the last paragraph, emerge and occupy the surface of the upper portion of its course.

Little or no geological mapping has been carried out between Coor-de-Wandy on the Upper Wooramel and Mount Narryer on the Upper Murchison, but between the latter hill and Tilly Gully (b), the older crystalline rocks give place to the almost horizontal sedimentary beds, which make such a prominent feature in the Woodrarrung Range (c), and which, there are very strong geological reasons for believing, represent the southward extension of the carboniferous rocks of the Wooramel.

In the valley of the Murchison River, somewhere below Bompas Hill, is a fairly large development of sedimentary beds. In the vicinity of the 14-mile crossing, some distance above the Geraldine Mine, and 80ft. by aneroid above it, is an exposure of what appears to be an older series of strata than that comprising the Woodrarrung Range. The lowest bed in the section is conglomerate and breccia, composed of angular fragments of quasi-vitreous quartzite, dipping to the east; the base of the conglomerate is not visible. A peculiar feature of some of the pebbles is that they are covered with slicken-sides, which, however, have no prevailing direction. A few yards lower down the river is a bed of quasi-vitreous sandstone overlaid by beds of cross-bedded sandstone and fine conglomer-

- (a) Annual Progress Report of the Geological Survey for the year 1902. Perth: By Authority, 1903, pp. 23-24; also Annual Progress Report of the Geological Survey for the year 1903. Perth: By Authority, 1904, p. 34.  
 (b) Lands Department Lithograph, 2m.  
 (c) Lands Department Lithograph 6m.

# MAP



## IS & SIGNS

A

A

Gn.

A





ate, trending north and south, and dipping east at an angle of 20 degrees. One of the sandstone beds has evidently been much faulted, for one of the beds is slickensided to such a degree as to produce surfaces as smooth and polished as plate glass.

Lower down the Murchison the sedimentary beds referred to in the last paragraph give place to the older crystalline rocks (gneiss, etc., with greenstone dykes), which occupy the country to a point on the river in the vicinity of the peg W. 1., on the boundary of Location 66/1135 (a).

Near this point, which is about twenty miles east of the sea coast, the Murchison River enters a narrow gorge, flanked by vertical walls of sandstone and grit. The junction between these sandstones and the older gneissic rocks, as can be seen by a section on the north bank of the river, is a fault dipping to the west. This sedimentary formation occupies the whole of the Murchison Valley as far as its mouth in Gantheaume Bay.

A traverse from Carnarvon to Northampton, *via* Gladstone, Hamelin Pool, and the Murchison River, near Mount Curious, in 1901 showed the staple formation to consist of sandstones, grits, etc., together with their decomposition products, indicating the continuity of the same geological formations seen outcropping on the high ground along the upper portions of the valleys of the Gascoyne, the Wooramel, and the Murchison Rivers.

No observations as to the actual discharge of the Wooramel and the Murchison Rivers would appear to have been made, so that no estimate of the amount of water absorbed by the sedimentary beds can be arrived at. From the available records, it seems that the rainfall of the district is fair, and that, after due allowance has been made for evaporation and run-off, a good deal of the rainfall must disappear underground, and be capable of being reached by wells or bore holes.

Having due regard to all the prevailing geological conditions of the country to which previous reference has been made, it may be said that, on the whole, the area occupied by the carboniferous and newer strata is favourable as regards the possibility of the occurrence of artesian water, whilst so far as can be judged by the present evidence, the chances of obtaining overflowing supplies is greatest on the lower-lying ground near the coast.

To the eastward of the boundary between the carboniferous and newer strata, no hope of obtaining a supply of artesian water exists.

A Geological Sketch Map, Plate I., accompanies this report.

A. GIBB MAITLAND.

**2.—On the country between the Ashburton and Minilya Rivers with a view to determining the northwards extension of the Gascoyne Artesian area.**

*(With a Map.)*

In the immediate vicinity of Onslow, the country is of an estuarine character, consisting of salt marshes and mangrove swamps with blown sand ridges containing large quantities of oyster and other recent shells.

For its water supply the town is dependent upon a number of shallow wells sunk in the sand, the water in which varies very considerably in quality, whilst the supply is limited, being entirely dependent upon the local rainfall.

Beneath the sand hills and swamps a heavy blue clay is met with, in the upper portion of which, if water is struck, it is of an extremely bad quality, whilst all attempts to obtain a supply by sinking through it have so far failed. Some years ago a bore was put down by the Government to a depth of 1,729ft., in which the first supply of water was struck at 1,015ft., which trickled over the surface at the rate of 20 to 30 gallons per diem. At a depth of 1,717ft. a further supply was cut which yielded 120 gallons per diem, the hydrostatic pressure being 10.82lbs. per square inch, and hydrostatic head 25ft. above the surface, the water being salt. The bore passed through shale for the greatest proportion of the depth and was discontinued in black shale, locally known as "black Jack."

Following up the Ashburton River in a southerly direction, large alluvial plains stretch east and west as far as the eye can reach, water being either obtained from the pools in the river bed or from wells sunk in the various groups of blown sand hills which here and there break the monotony of the flats.

This class of country extends for a distance of about 50 miles, where it is suddenly terminated by an outcrop of crystalline rocks, which from this point southward present a fairly bold escarpment to the westward.

Between the Ashburton and Yannarie River are large plains of a more or less flooded character, and it is on to these that the last-mentioned river discharges its waters, at a point upon the telegraph line about 65 miles from Onslow, whilst the plains in flood time drain into the salt flats and marshes lying upon the eastern side of Exmouth Gulf.

This plain country extends up the Yannarie as far as Jane Well (C. 29), from which point the country rises rapidly, the

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surface being covered by a red sand, with occasional outcrops of limestone.

At Nganyou Pool (C. 26) the crystalline rocks with quartz reefs make their appearance, overlaid by limestone conglomerate, the junction of the two formations following a line slightly to the east of north.

From Wogoola Station (Cameron and Clark's), upon the Yannarie at its junction with Emu Creek, a road runs south-westward to the Winning Telegraph Station, along which the crystalline rocks outcrop for about six miles to be suddenly replaced by shales. At a point seven miles to the westward of the station a well has been sunk in them to a depth of 80 feet, at which depth a good water supply was struck. These shales are highly altered (locally called kaolin); this change from the normal dark blue is in all probability due to the leaching subsequent to the oxidation of the pyrites, which often occurs associated with them in considerable quantities. At a point 10 miles west of the station another well has been sunk in the shales to a depth of 162 feet, but so far no supply of water has been struck. In this well some green fossiliferous shales were passed through, but these have now all weathered away and only portions of a cast of an ammonite were obtained from Mr. Cameron.

For the next 10 miles a series of clay pans and sandy flats are crossed, after which low shale hills strewn in patches with much quartz and ironstone rubble are passed over, until the telegraph line is reached.

To the northward of the Telegraph Station at Winning and to the westward of the line are a series of altered shale hills, which present a cliff-like face to the eastward, the beds of which have a distinct, although slight dip to the north-eastward.

Between Winning and Towera Station on the Yannarie (Mr. Twitchin's), travelling due east, are a series of low shale hills, of which Mt. Forrest is the highest, then sandy flats are crossed to within a distance of 10 miles of the river, where a shaft has been sunk by the Minilya Roads Board to a depth of 62 feet, in dark shale, without striking water, whilst immediately to the eastward of this point the crystalline series again appear and continue for the remainder of the distance to the station.

From the dry well just mentioned the boundary of the granitic rocks can be traced in a south-easterly direction, sweeping past the Round Hill (which is sandstone) upon the eastern side; thence on south of A. 43 Cairn, crossing the Lyndon River just below marked tree A. 31; from there striking back to the north-east of Sugar Loaf Hill, crossing the flooded flats of the river, which it follows close upon the eastern side to A. 36, where it again crosses, following the White Quartz Hill upon the western side, from which

point it strikes south-easterly on to the Minilya to a little east of Williambury Station, up to which point it has been mapped in by Mr. A. Gibb Maitland, the Government Geologist.

Traversing the river westward from A. 31, limestone conglomerates are seen resting directly upon the crystalline series in the bed of the river, to be overlaid lower down by shales. Between Windalia Pool, A. 29, and Chngareyardoo, A. 49, which is upon a branch creek to the southward, there is an outcrop of heavy schistose boulders associated with crystalline limestone; these may probably indicate shallow ground, since lines of these boulders with parallel lines of foliation are often seen outcropping, whereas if they had been a portion of the glacial series described by the Government Geologist they would have been more disturbed and ice scratched. This is the only locality in the whole area where there appears to be anything like shallow ground within the basin.

About one mile north-east of Cordalia Well, near A. 51, a fossiliferous limestone ridge rises from the plain which strikes in a north-westerly and south-easterly direction, with a well-defined dip to the south-westward. The fossils in these beds are similar to those met with upon the Irwin River, and therefore it may be assumed that these rocks belong to the Lower Carboniferous series.

To the south-westward of this ridge is a well defined range of hills, the basal beds of which are shale, whilst the capping is sandstone or quartzite; these latter beds vary from 20 to 70 feet in thickness.

This range attains its greatest elevation at the south end in Moogooloo Peak, which forms a conspicuous landmark, whilst owing to the vertical cliff-like faces presented by the heavy quartzite capping it is most difficult to climb.

This range appears to be the northern extension of the Kennedy Range, which is also similarly capped.

The beds of this range near A. 51 have a much steeper dip than at any other point noted in the district, therefore, it is either only local, or the dip of this series flattens greatly to the northward, which is quite possible, and would account for the plains without rock outcrops.

Between Cordalia Well and Winning the country is mostly low and rolling, the ranges dying away to the northward of the river, the presence of the various formations being only determined by the nature of the soil.

To the westward of Winning, after the shale hills are crossed, the surface of the country consists of a series of calcareous flat, which give place to low shale hills near the Cordalia Creek.

About ten miles west of that creek, at A. 8, there is a bold limestone range, the rocks of which dip at a low angle to the westward, whilst between it and the coast are a series of flats and sand ridges.

South from Winning along the telegraph line to the Lyndon River the country is undulating, the soil being mostly sandy and calcareous.

The beds of this district fulfil all the conditions necessary to an artesian area, consisting as they do of a series of pervious sandstones and limestones interbedded and overlaid by impervious shales of considerable thickness, the whole having a uniform dip to the westward or towards the coast. At the junction of the artesian series with the granite, the surface elevation varies from 450 to 500 feet above the sea level, the coast being about 75 miles distant; but since about 15 miles of coastal country has practically no elevation, this fall may be condensed into 60 miles, which represents from 7 to 8 feet per mile; therefore as the water level at or near the junction varies from 50 to 100 feet (according to the elevation of the surface), it will follow that a sufficient hydrostatic head cannot be obtained to cause water to rise above the surface until a distance of from 12 to 15 miles west from the outcrop of the crystalline series is reached, although in the intervening distance no doubt sub-artesian water (water rising in bore but not overflowing) will be obtained.

In support of the theory that this is an artesian area, we find in the Lyndon Valley and to the southward the unbroken continuation of the rock series, forming hill ridges, which constitute the proved area of the Gascoyne.

In conclusion, it may be stated that a very fine stretch of pastoral country was passed over, which at the present time is practically valueless, because all attempts to obtain a water supply by the means of shallow wells has so far proved futile.

HARRY P. WOODWARD,  
Assistant Government Geologist.

### 3.—The Phosphatic Deposits near Dandaraga.

(With a Map and 8 figures.)

*Preliminary Note.*—In the month of September, 1906, a sample of a greenish ferruginous sandstone, which, on examination, was found to contain 14.96 per cent. of phosphoric acid, was received at the offices of the Geological Survey. In view of the great value to the State of the occurrence of a suitable mineral phosphate, it was considered desirable to have a geological examination of the deposit made in the field, and also to carry out certain investigations in the laboratory in connection therewith.

Mr. Campbell, Assistant Geologist, was accordingly instructed to visit the district to inquire, *inter alia*, into the extent of the deposit, its mode of occurrence, its mineralogical constituents, etc., and the utilisation of the deposit. This officer devoted a week to the investigations in the field, and made a collection of the deposits in illustration of his report. These samples were placed in the hands of Mr. Simpson for investigation in the Survey Laboratory, and a typical series are now in the Geological Survey Museum.

The report of Mr. Campbell is accompanied by a plan (Plate III.) showing the extent of the phosphatic deposit, so far as is at present known, together with a series of four photographs and four geological sections. Mr. Simpson's report contains several analyses of the different classes of the deposit.

It appears the deposit occurs in a series of beds, which have been followed across country for a distance of about 22 miles, and the phosphatic rock exposed in several places. The deposit appears to have been originally found on the Midland Railway Company's concession, though the field observations prove it to extend into Crown lands. So far as observations have as yet been carried, there appear to be three distinct classes of material amid the phosphatic deposits (a.) weathered rocks containing from 0.54 to 2.10 per cent. of phosphoric acid; (b.) ferruginous sandstones, containing phosphates mainly of iron with from 7.25 to 15.13 per cent. of phosphoric acid, the iron phosphates occurring as dufrenite and vivianite; and (c.) fossil bone and coprolite rock, containing from 15.32 to 39.34 per cent. of phosphoric acid.

The bone bed has been proved to be about three feet thick, whilst the underlying ferruginous sandstone, which has been more or less phosphatised by the interaction of ironstone and phosphoric acid derived from the bone beds, is at least 7ft. in thickness. The bone bed is of course the most important of the deposits, and it is possible that prospecting may result in portions of the deposit



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being found to be much richer in phosphoric acid than any of the outcrops yet tested.

The matter of the geological age of the deposit is one of inference only, but I am inclined to regard it as being the northern extension of the Gingin tertiary strata.

These discoveries are of importance, and should act as a stimulant to the search for similar phosphatic deposits in that portion of the Great Coastal Plain, which extends from Perth to Geraldton, for they may easily prove to be more extensive than at present known. So far as can be judged from what is at present to be seen, there seems to be the material for a remunerative industry if properly and judiciously followed up.

A. GIBB MAITLAND,  
Government Geologist.

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The locality where phosphatic deposits have been found on the Midland Railway Company's concession is on a north and south line of country passing four miles west of Dandaraga, which latter place is 22 miles to the westward of Moora, and is connected with it by a well-made road. The intervening country is largely a sandplain until about 14 miles out from Moora, when a series of low limestone hills are met with showing a considerable fertility of soil. The hills rise rather higher on the west side of Dandaraga and form the dominant range in the district. These hills are mostly well wooded, and are composed of ferruginous sandstone, they form a line of steep escarpments and bluffs towards the west, from the foot of which extend many miles of sandplains, mostly destitute of timber. These ferruginous beds are nearly horizontal, with a slight inclination to the east in places, and contain indurated bands on the top of one of which the phosphatic bed or beds occur, and are seen on a subsidiary line of escarpments about a mile back from the main line of which Cowalla Bluff forms a part, and also at the base of some white limestone or chalk-like hills thirteen miles to the north. These localities extend over a distance of about 22 miles.

The place where the phosphate samples were first obtained is about six chains south-easterly from the south-east corner of Location 957 (James Burnett's); here the upper portion of the outcropping ledges of rock on the track show about one foot in thickness, having a mottled green colour, which attracted the attention of Mr. James Gardiner when driving along the track, and he collected some samples and forwarded them to this Department

and to the Government Analyst, when they were found to be phosphatic, containing from 10 to 15 per cent. of phosphoric acid. The source of this acid is a bone bed that overlies it and which being softer has decomposed at the surface of the ground, leaving only a few blocks scattered about. It contains fragments of bone, teeth or tusks of saurians and whitish nodules (so-called coprolites), which latter have been probably formed by the aggregation of phosphate of lime. The report of the Mineralogist and Assayer shows that the green colour of the rock is due to the mineral dufrenite, the phosphoric acid having combined with peroxide of iron to form that mineral. He also reports the presence of both vivianite (hydrated phosphate of iron) and wavellite (hydrous phosphate of alumina). The beds have thus both rock and organic phosphates.

Since my visit I have been shown specimens obtained from holes sunk adjacent to this outcrop; these show a better grade of phosphate, and that the bone bed is at least three feet thick, and that the green alteration of the bands of sandstone extends down to ten feet depth in the deepest of the holes, which have bottomed on to very hard sandstone.

The same formation is to be seen at the ledge of rock,  $\frac{3}{4}$  mile to the north near Mr. Burnett's house, but the bone bed is not so much in evidence there. (Figures 1 and 2, and Mineral Specimens 6852, 6877-80.)

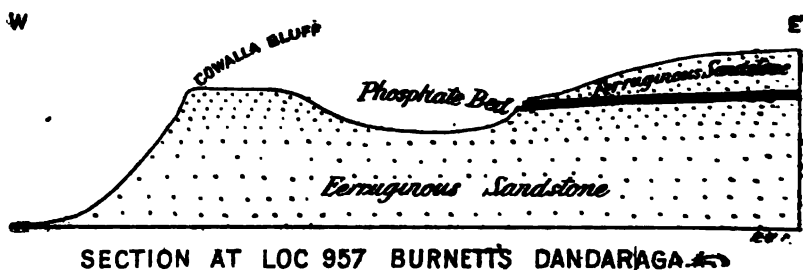
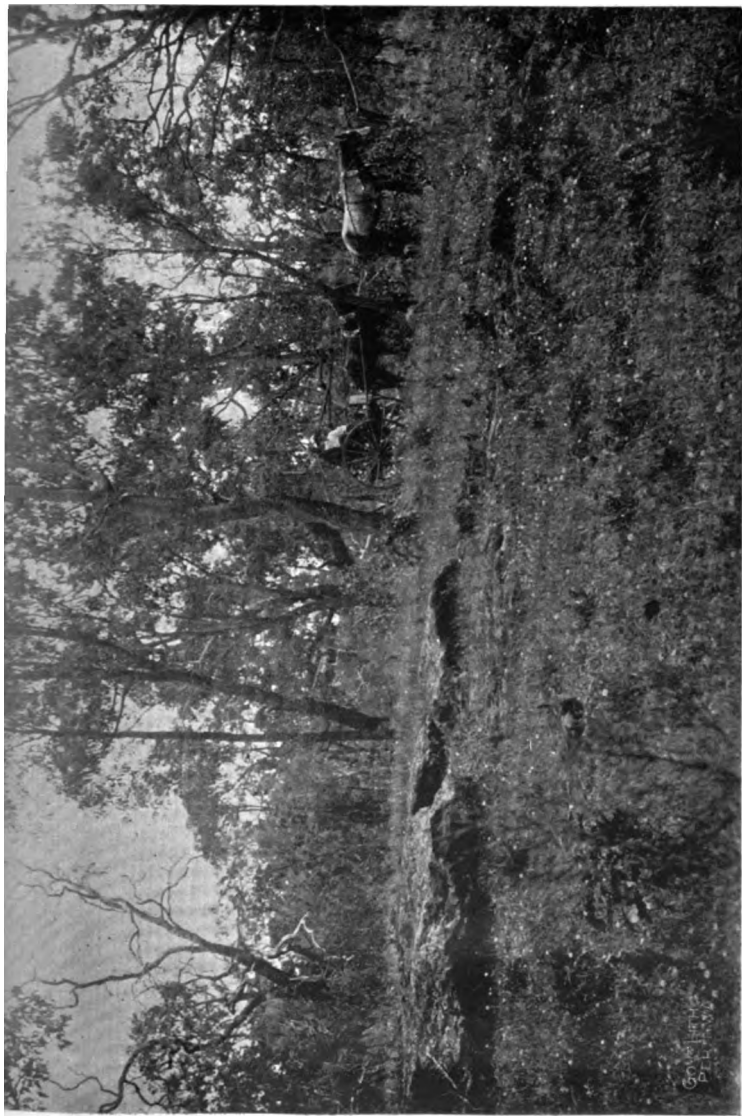


FIG. 1.

Similar beds occur about  $4\frac{1}{2}$  miles in a direct line southerly at the western side of Location 1110 (Mr. Bower's); there is here a low escarpment to the west. The phosphate bed probably underlies the surface across from there to an eastern escarpment of a small gully, where there is a small cave known as the "Hole in the Wall," a distance of about 30 chains. The upper portion of this ledge is green-coloured, and is phosphatic, and a tank which has been excavated in it shows that the bone bed also exists here to a depth of six feet at least. (Figures 3, 4, and 5, and Mineral Specimen 6884.)





Phosphate beds, 6 chains S.E. from S.E. corner of Loc. 957, near Dandaraga, looking E.

Negative 281.



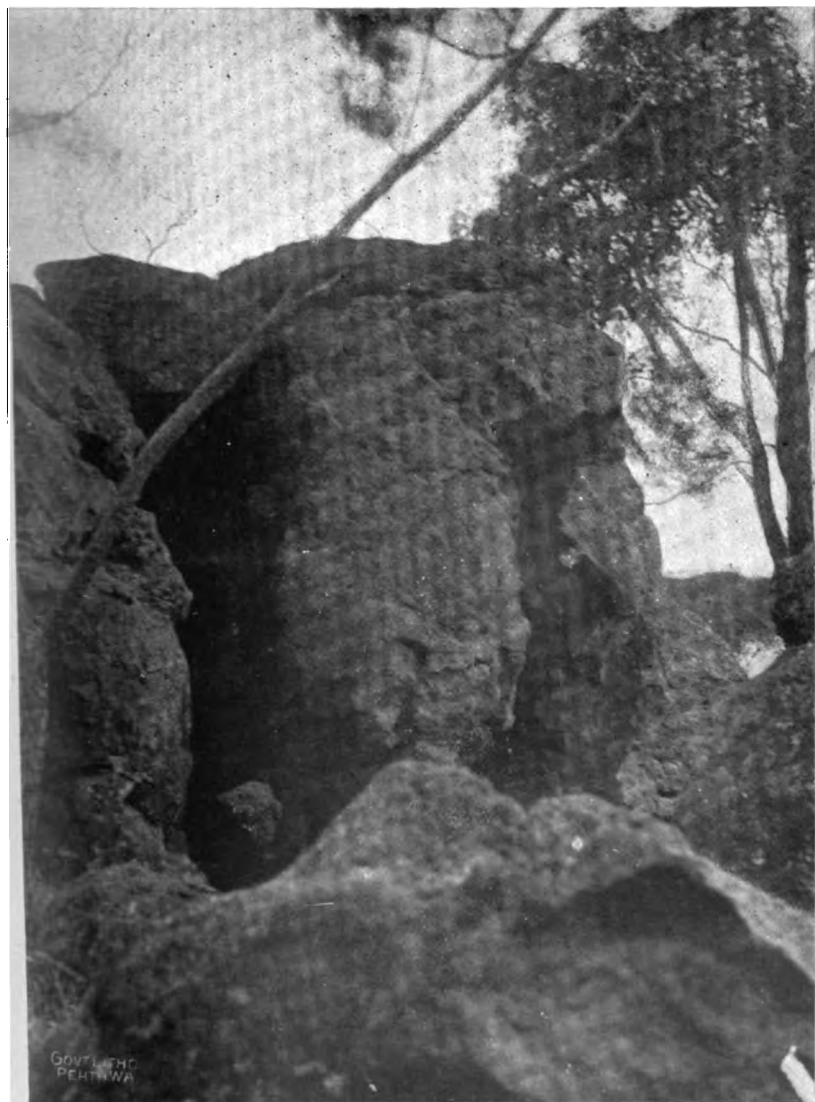




Phosphate rock forming upper surface of escarpment of Ferruginous Sandstone at  
Loc. 1110, near Dandaraga, looking E.

Negative 283.



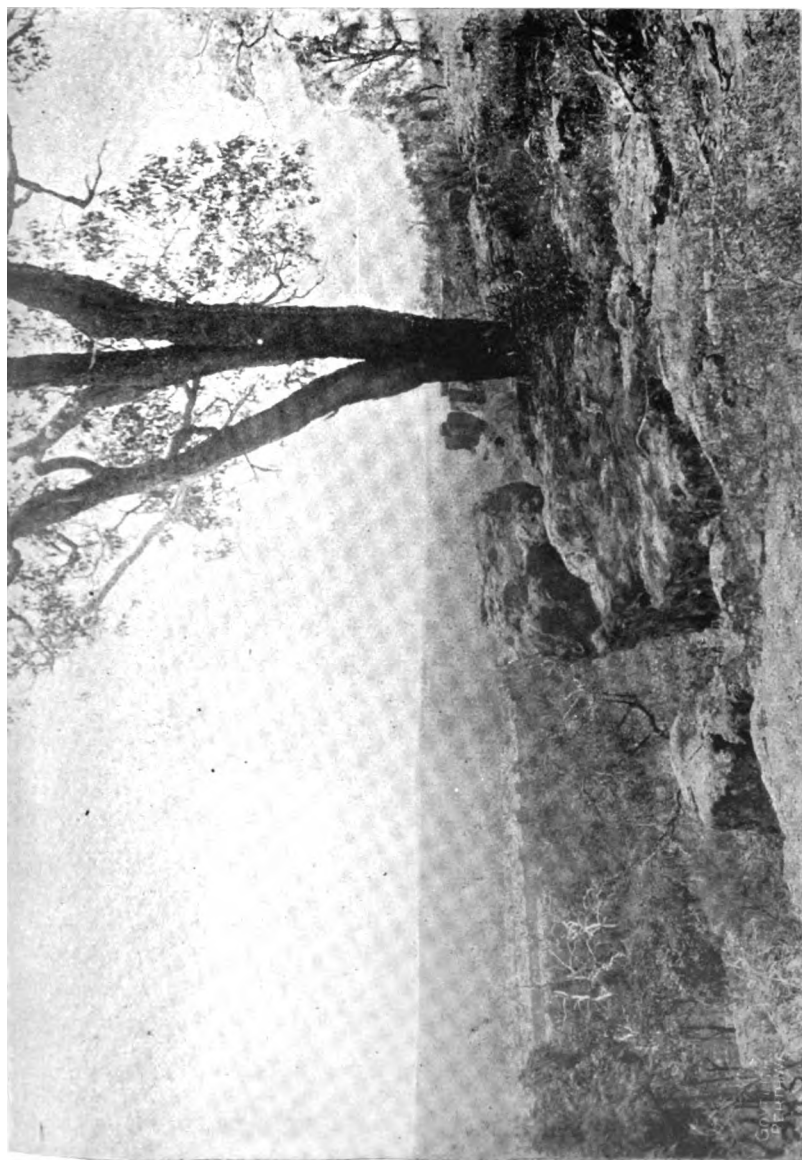


Cave, known as "Hole in the Wall," on Loc. 1110, close to Fig. 4.

Negative 284.







Phosphate bed above caves, 2½ miles N.E. from Yandan Hill, near Yatheroo, looking E.

Negative 285.







Four miles south again from here there is a conspicuous cliff facing the north, known as "The Caves." These caves have been formed by the action of the water penetrating cracks in the hard

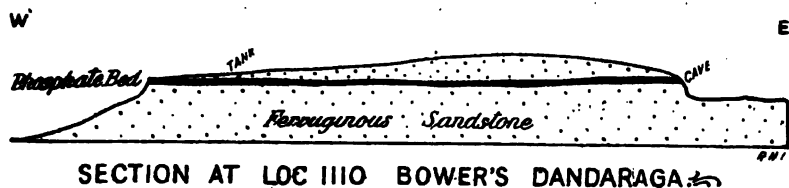


FIG. 3.

ledge, and washing away the underlying softer rock. Heavy rain had fallen the day before my visit, and the fresh marks of running water were very plain. Some of the caves are over 50ft. long, and, in some places, 8ft. high. The upper surface of the ledge has the green-coloured rock, and above it are fragments of the bone bed and nodules. The hill top is wooded to the face of the cliff, along the foot of the cliff also there is a strip of large timber growth, but south-westerly from here the timber becomes scarcer, and at  $2\frac{1}{2}$  miles is the bare Yondan Hill, which I visited, but did not go beyond as the country looked unpromising, and any further outcrop of the phosphatic bed would probably have to be sought for nearer Yatheroo. (Mineral specimen 6981-2, and Figure 6.)

Northwards of Cowalla the escarpments disappear, and the line of hills is broken up, the timber growth lessens, and I did not hear of any ledges of this ferruginous green rock about there.

In Location 400, Mordo, a tank has been excavated in either a fine-grained ferruginous sandstone or a decomposed greenstone, the upper portion of which has a greenish colour and contains from 2.10 per cent. of phosphoric acid; but I did not see any sign of the bone bed, as a bed of laterite of about a foot thickness conceals the underlying sandstone. The country around is flattish with only scanty timber. (See Mineral Specimen 6985.)

Two miles farther north is Pickera Pickera, where a similar rock outcrops near the track (Mineral Specimen 6983) with only .54 per cent. of phosphoric acid. It is quite possible that the bone bed may never have existed here, and that the phosphoric acid at both these two locations may have been the result of the denudation of the bone bed in the neighbourhood.

Six miles farther north at Wathingarra (Emu Hill) there is a white limestone or chalky hill, the western foot of which is intercalated with sandy seams, and with them is a bone bed outcropping near the track. The greater part of the hill is composed of a very pure limestone, a sample from the top of the hill, when examined,

showed a slight trace of phosphoric acid ; some silicified pieces of wood were found on the hill, probably caused by the same conditions that have solidified a white sand and gravel at Location 867 (Whitfield's), about three miles south-easterly from here, into a quartzite bed from 4ft. to 8ft. thick, which underlies about 6ft. to 10ft. of laterite. Both here and at Emu Hill there is a total absence of the ferruginous zones that are such a marked character of the other localities mentioned. (Figures 7 and 8, and Mineral Specimens 6886-90.)

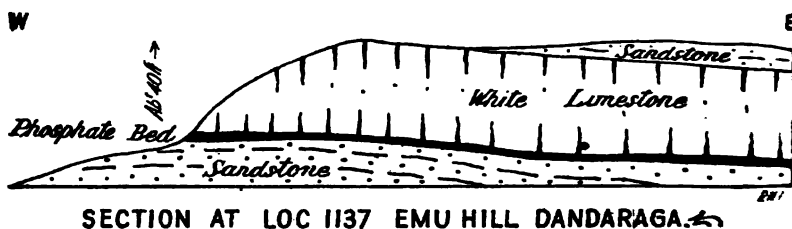


FIG. 7.

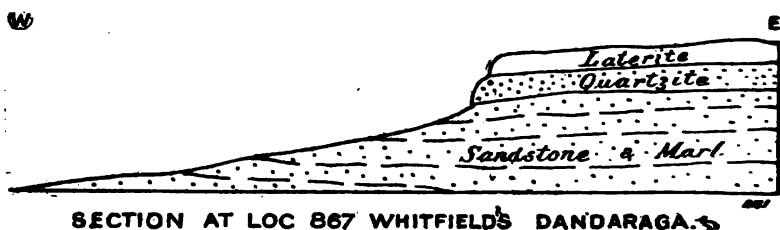


FIG. 8.

In each instance the bone bed evidently forms part of the sequence of the beds in the district, all being of one geological series, and it may be found that the bone bed is repeated at a higher or lower horizon on the series, and that the Emu Hill bed is not the same as that at Location 957.

In the map accompanying the report of the then Government Geologist, Mr. H. Y. L. Brown, the Gingin, Yatheroo, and Dandaraga patches of limestone are shown, and both that and the "ferruginous claystone, limestone, sandstone, and grit" are classed as of mesozoic age (Oolitic period of the Jurassic series), and on pages 11 and 13 of his report, he says that the average thickness of these beds where best developed is 400ft., and average elevation about 600ft. above sea level, the surface accumulations of sand preventing its being ascertained whether the limestone over or underlies the ferruginous rock of the district.

The fragmentary and greatly decomposed state of the specimens that I have obtained from the outcrops of the bone beds

prevents much assistance being derived from them towards the identification of their geological horizon at present. There is, however, a great resemblance of the characteristics of the bone bed series with the ferruginous sandstones of the Greenough River district which contain Jurassic fossils, and Mr. H. Y. L. Brown has mapped them as being of the same series.

In both localities the current bedding of the sandstones and the ferruginous bands of floors denote that they were formed in either estuaries or lagoons which were liable to be dried up at times causing probably the destruction of most of the marine creatures inhabiting them.

I did not hear of the occurrence of phosphatic material at any other tanks or wells along the route of travel between the above-mentioned localities, and my inquiries were necessarily more particularly directed towards the existence of the green-coloured rock, which alone appears to have been noticed by residents of the district, who, however, thought that the colour was due to the presence of copper. At Cowalla, the horizon of the phosphate bed appears to be below the summit of the bluff, but it being very steep and disadvantageous as a working ground, I did not ascertain whether it existed there. At Emu Hill there are no ferruginous ledges nor green-coloured rocks, but the bone bed probably extends along the outcrop of that horizon of the limestone hills. Around here the timber is scanty, and white gum has replaced the red gum, the neighbourhood of Cowalla being, I understand, the northernmost limit of that tree, and Yatheroo that of the jarrah. The strong growth of vegetation in portions of the district is due probably to the existence of both limestone and phosphate beds, independently or in conjunction.

It will be seen from the above particulars that there appears to be here the material for a remunerative industry, for the phosphatic deposits evidently extend over a considerable area.

The bone beds somewhat resemble the Cambridgeshire coprolite beds in England, of which I have had experience, and the procedure for the exploration and working of the deposit will be much the same, viz., by trial holes, and then excavating the open trenches, first stripping down to the bed and working up hill until the depth reached makes it too costly for the amount of phosphate obtained. The material from the bone bed would have to be concentrated by screening, washing, or hand-picking, but a difficulty presents itself through the softness of the phosphatic nodules and bones, which will require great care to prevent that material from being lost in the sandy matrix.

The Cambridgeshire coprolites and the South Carolina nodules are readily separated by either washing or screening on account of their hardness. After concentration, the phosphate lumps would

then have to be ground in roller pans, when it could be sold as raw phosphate, or be manufactured into superphosphate by mixing with sulphuric acid, which produces a hydrous and water-soluble phosphate, and a sulphate of lime or gypsum.

The raw phosphate does not decompose readily, and may even take years to benefit the ground ; in the superphosphate form the phosphoric acid is more readily assimilable, and is therefore more in demand when not too costly.

The green-coloured rock which underlies, or is intercalated in the bone bed, would have to undergo a different treatment, which is referred to by Mr. Simpson in his report attached, and possibly special treatment to meet the special material would have to be devised.

For the convenience of prospectors, it may be mentioned that for the field examination of samples dissolve in warm nitric acid, then strain off the residue to a clean solution ; when cold put a few drops into a solution of ammonium molybdate, when, after a few minutes, a bright yellow precipitate should appear. If the material is insoluble in nitric acid, it may be fused in a sodium carbonate bead, and then dissolved in this acid (see p. 102 Brush and Penfold's Determinative Mineralogy). A great deal of useful general information is given on the subject of phosphates in a pamphlet by Dr. Charles Chewings, issued by the Government Printer, Adelaide, 1903.

W. D. CAMPBELL,  
Assistant Geologist.

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## Appendix I.

LIST OF SPECIMENS IN THE GEOLOGICAL SURVEY MUSEUM  
FROM DANDARAGA.

Registered No.	Rock.	Obtained from.	Locality.
6977	Phosphate of Iron Rock ...	Surface	Near S.E. corner of Loc. 957, Dandaraga
6978	Do. do. ...	do.	Near S.E. corner of Loc. 957, Moora district
6979	Bone Bed ... ..	do.	do.
6980	Do. ....	do.	do.
6981	Laterite ... ..	do.	The Caves
6982	Laterite with Phosphate of Iron	do.	do.
6983	Laterite with Phosphate of Iron, Weathered	do.	Loc. 132, Pickera Pickera, near Dandaraga
6984	Phosphate of Iron Rock...	do.	Loc. 1110, near tank, Dandaraga
6985	Do. do. ...	do.	Mardo tank, Loc. 400, Dandaraga
6986	Quartzite capping of hill	do.	Loc. 867, Whitfield's, Dandaraga
6987	do.	do.	do.
6988	Silicified wood ... ..	do.	Loc. 1187, Wathingarra (Emu Hill), Dandaraga
6989	Bone Bed ... ..	do.	do.
6990	Limestone from top of hill	do.	do.
6992	Chalcedony ... ..	do.	1 mile east of Moora, Dandaraga
6993	Ferruginous Quartzite ...	do.	do.
7017	Bone Bed ... ..	3ft. deep	Near S.E. corner of Loc. 957, hole 5 feet deep, 3 chains east of road

## Appendix II.

## COMPOSITION OF THE PHOSPHATIC ROCKS.

I have examined the series of phosphatic rocks collected by Mr. Campbell at Dandaraga as far as at present possible with the limited staff at my disposal.

Roughly three main classes of material were included in the samples.

A. Weathered rocks doubtfully phosphatic.—The results obtained on these were:—

L.2613. Average of M6983.—Weathered ferruginous rock with a little green staining;  $P_2O_5$ , 0.54%.

L.2616. Average of M6985.—Weathered greenstone (P).  $P_2O_5$ , 2.10%.

Neither of these samples are of any value whatever.

B. Ironstones carrying phosphates, mainly of iron.—The analyses of these are:—

L.	Total P <sub>2</sub> O <sub>5</sub> .	Ferric Oxide.	Silica and Insoluble Silicates.	Water and Organic Matter.	Carbonic Acid.
2600	7.25	32.14	47.54	7.35	Trace
2601	9.63	...	...	...	Strong trace
2614	15.13	...	...	...	Strong trace
2615	7.41	...	...	...	Trace

**2600.** Average of **M6977**.—Ferruginous sandstone impregnated with Dufrenite (hydrated phosphate of iron). Sample contains only 0.08 per cent. of lime. Of the phosphoric oxide present 6.63 per cent. is insoluble and 0.62 per cent. soluble when digested for a week with 1 per cent. citric acid solution. Only one-tenth therefore of the total phosphoric oxide present is available for plant food in its present state.

**2601.** Ink-coloured portion of **M6978**.—This is similar to the previous sample, but appears to contain as well as Dufrenite a second iron phosphate, Vivianite.

**2614.** Typical specimen of **M6982**.—Light brown siliceous ironstone with paler nodules.

**2615.** Average of **M6981**.—Heavy dark brown siliceous ironstone, with light brown concretions.

The first of these four samples is similar to the first sample brought to Perth from this locality. It showed 14.96 per cent. of phosphoric acid, and my report upon it is applicable to the present (B) set of samples.

"For a fertiliser the sample as submitted is low in phosphorus, and the amount of that constituent available for plant food in its present state appears to be very minute, dilute citric acid having an extremely slow effect upon it. Before any practical use could be made of this material means must be resorted to to render the phosphoric oxide soluble. The usual method of treating rock phosphate, viz., converting into superphosphate by treatment with sulphuric acid would be inapplicable in this case where such a large proportion of iron oxide is present. The most feasible method of utilisation seems to be the manufacture of 'Precipitated Phosphate' by solution of the phosphorus and precipitation with lime or calcium sulphide. By this means a very rich fertiliser could be obtained. If dufrenite be the only phosphatic mineral in this deposit it is evident that the highest proportion of phosphoric oxide that could be present in any part of it would be that present in pure dufrenite, viz.:—28 to 32 per cent., whilst the average would be well below that owing to admixture of sand, clay, and limonite. It seems probable, however, that the original source of the phosphorus was coprolite or bone phosphate, which by interaction with iron compounds has given rise to dufrenite. Either of the former phosphates would be of more value than the last named, being both richer in phosphoric oxide and readily converted into superphosphate."

In years to come, when the steel industry is an established fact in Australia, there will probably be a demand for the more ferruginous samples for the simultaneous manufacture of basic steel and Thomas' phosphate.

C. Fossil Bone and Coprolite Rock. The prediction that the iron phosphate was a secondary mineral derived from the interaction of ironstone and phosphoric acid derived from bone or coprolite beds has been verified by Mr Campbell.

The following are analyses of typical samples of these beds:—

L.	Total P <sub>2</sub> O <sub>5</sub> .	Lime.	Ferric Oxide.	Silica and Insoluble Silicates.	Water and Organic Matter.	Carbonic Acid.
2602	18.26	15.80	26.42	21.27	7.83	Very small
2603	39.34	...	...	1.87	...	Small
2604	26.26	...	4.17	28.06	2.50	Small
2610	15.32	...	29.31	27.02	9.60	Very small

**2602.** Average of **M6979**. Yellowish and greenish mottled rock with base of ferruginous sand carrying a little dufrenite, and enclosing numerous fossil bones and lime phosphate nodules (coprolites) of all sizes. Most of the phosphoric acid in this sample is present as lime phosphate, a little, however, is present as iron phosphate (dufrenite) and a little as aluminium phosphate (wavelite). The whole of it is "acid soluble"; 7.06 per cent. of the phosphoric oxide is soluble in 1 per cent. citric acid in one week and is therefore available for plant food, 11.20 per cent. is insoluble in this solution. Such material, if very finely ground, might be used with advantage on the swamp soils of the South-West of this State, but being very slow in action compared with superphosphate would probably not be received with much favour by the farmers. Its value at the rates published by the Agricultural Department would be £2 17s. per ton. A higher grade sample of similar material has been presented to the Department by Mr. Jas. Gardiner.

**2603.** Bone (tusk?) from **M6979**. This is a fair sample of the large pieces of bone present in the previously described sample. It contains 85.88 per cent. of lime phosphate and only a trace of iron.

**2604.** Phosphatic nodule or coprolite from **M6979**. Contains 57.33 per cent. of lime phosphate, and is therefore similar to much of the lower grade coprolite and pebble-phosphate which is converted into superphosphate.

**2610.** Average of **M6980**. Similar to **L2602** already described, but contains no visible iron phosphate and is more porous and friable, having apparently been subjected to considerable leaching action.

Both of the samples of the bone-coprolite beds examined are too low in phosphoric oxide to be worth converting into superphosphate. That richer samples are, however, to be obtained is shown by Mr. Gardiner's specimen. With cheap locally made sulphuric acid even the lower grades might be used for the production of high-grade precipitated phosphate.

If the bones and coprolites can be successfully separated from the enclosing non-phosphatic sand rock by coarse crushing and screening, or otherwise, an excellent high-grade raw material would be obtained, carrying from 60 to 70 per cent. lime phosphate, and therefore well suited for conversion into superphosphate.

The latest published local values for phosphoric acid in fertilisers are as follow:—

	s.	d.
Water-soluble ... ..	5	2 per unit.
Citrate-soluble ... ..	8	10 " "
Acid-soluble ... ..	2	7 " "
P <sub>2</sub> O <sub>5</sub> in bones, offal, etc. ... ..	3	0 " "

EDWARD S. SIMPSON,  
Mineralogist and Assayer.

#### 4.—Notes on a Meteorite from the Nuleri District of Western Australia.

(With 6 figures.)

The small meteorite (5025) here described, was presented to the writer by W. R. Feldtmann, Esq., in 1902, with the information that it was obtained from a prospector, who said he picked it up in the uninhabited interior somewhere about 200 miles east of Sir Samuel. According to this it would have been found either close to or within the boundaries of the Nuleri Land District, and it is proposed therefore to call it the Nuleri meteorite.

Its general appearance is shown by Figs. 9 and 10. It is a Siderite of the octahedrite type. Its total weight was 120.2 grammes; extreme length, 60mm.; extreme width, 46mm.; extreme thickness, 22mm. It is evidently not an entire boloid but a small fractured portion of a large mass, probably fractured naturally in falling, since the fractured surfaces have a crust very similar to that on the original external surface. About one quarter of the surface exhibits the typical external appearance of a siderite being pitted and covered with a glazed surface, varying in colour from black to dark brown. The remainder of the surface is formed by broad faces of the octahedron covered by a thin coating of black magnetite. The mass is penetrated deeply in places by fractures along octahedral cleavage planes. A number of minute moist globules, brownish yellow in colour, occurred on the cleavage faces when first received. These proved on examination to be iron perchloride ( $\text{Fe}_2\text{Cl}_6$ ), showing that lawrencite (iron protochloride) is a constituent of the mass.

Taking advantage of the deep fractures, portions weighing in all 10.7 grammes, were broken off with a cold chisel for chemical and structural examination, leaving the main mass weighing 109.5 grammes.

*Internal structure.*—A cleavage flake, 30 millimetres long and 3mm. thick, was carefully polished on one side and then etched with nitric acid of normal strength for about two minutes in order to develop the internal structure. This was found to be very interesting, a beautiful damascened structure being brought out. This is well shown in Fig. 11. A similar structure is recorded by Fletcher as occurring in the Youndegin iron, though nothing resembling it appears on the fragment of that iron in the Perth Museum.

The different constituents observed were three, viz.:—

(1.) A dull grey iron-nickel alloy forming the greater part of the surface. This was evidently the constituent most attacked by the acid.

(2.) A much brighter iron-nickel alloy, but little affected by the acid and occurring in numerous long slightly curved lenticular





FIG. 9. Obverse.



FIG. 10. Reverse.

Nuléri Meteorite. (Natural size.)

Photo. : E. S. Simpson.







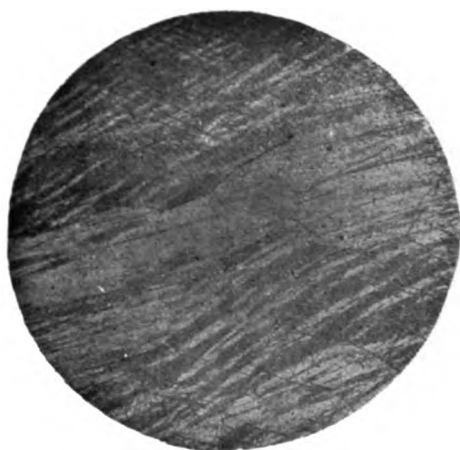


FIG. 11.



FIG. 12.

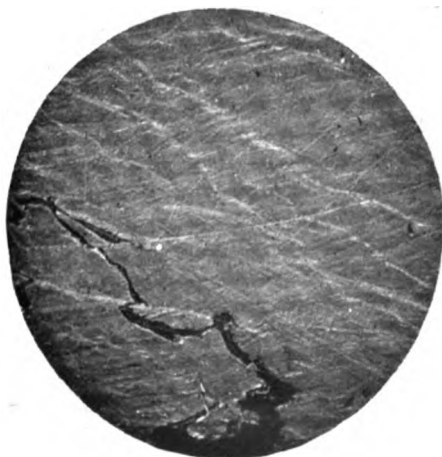
Nuléri Meteorite, etched sections. (Enlargement, ten diameters.)

Photo. : E. S. Simpson,





**FIG. 13.**



**FIG. 14.**

**Nuléri Meteorite, etched sections. (Enlargement, ten diameters.)**

**Photo. : E. S. Simpson.**





is, for the most part from one-twentieth to one-fifth of a millimetre in thickness, as seen in Figs. 11 and 12. There are two placing sets of these lenticles each roughly parallel to one of the principal cleavages, one being much more developed than the other. No lenticles appear to follow the third cleavage. The second, less prominent set, is best seen in Fig. 13, but may also be seen in Fig. 11. On one portion of the surface this mineral is much more largely developed, forming an M shaped area, one leg of which is seen to cross the centre of Fig. 12.

(3.) A brilliant tinwhite mineral occurring in very small amount, and that very irregularly distributed, being confined to two widely separated areas. Its outline at one of these points resembles Arabic writing, as seen in Fig. 14; at the other shown in Fig. 13 there is a singular tabular crystal parallel to a cleavage, about 2mm. long and 0.3mm. wide. In both cases the illumination of the surface when the photographs were taken was such as to suppress the brilliancy of this mineral. It appears therefore to be almost black. This mineral is probably schreibersite (phosphide of iron and nickel).

The only other notable point brought out by etching was the principal cleavage in three directions at an angle of 60 degrees to one another, the fourth cleavage being parallel to the surface of the plate.

*Chemical composition.*—A fragment of the meteorite weighing 5 grammes was carefully cleaned by filing, etc., and finally polished, with the results given below. For comparison I have added the analyses of three of the only other five undoubtedly iron meteorites yet discovered in this State. No analyses would appear to have been made of the Mooranoppin and Mt. Stirling irons :—

... .. {				Hamersley Range (Roebourne).	Ballinacree (Mt. Erin).	Youndegin.	Nulert.
Class.				Om	Off	Og	P
...				90.91	89.91	92.67	93.57
...				8.33	8.85	6.46	5.79
...				.69	.74	.55	.41
Sodium				Nil	Nil	.42	.09
...				Nil	Trace	Trace	Trace
...				Trace	Trace	.04	.01
Manganese				1.16	.50	.24	.13
...				Trace	Trace	Nil	Trace
...				.01	Trace	Nil	Nil
...				...	...	...	Trace
Total				100.00	100.00	100.38	100.00
...				7.78	7.8	7.86-7.72	7.79

Assuming that the whole of the phosphorus is present as schreibersite, the mineral composition of the meteorite would be

Schreibersite	..	..	..	0.84 per cent.
Nickel-iron alloys	..	..	..	99.16 per cent.
Lawrencite	..	..	..	Trace.

Owing, however, to the very irregular distribution of the constituents disclosed by polishing and etching, and to the fact that only a small fragment (15 grams.) could be used in making analysis, the chemical composition given above must be looked upon as only approximate for the whole mass.

EDWARD S. SIMPSON,  
Mineralogist and Assayer

1

rod

ston  
four  
times

rois  
Unac  
1/2 & 6  
oil

cam



50

## NO 26 PLATE IV.



1	6
4' <i>ter</i>	1' to 1'
3' <i>red</i> Shells	106' . 11' 6"
<i>rod</i> 9' <i>colate</i> sand	236' . 35'
<i>stone</i> <i>mm</i> sand	9' . 44'
<i>covered</i> 9' <i>colate</i> clay	8' . 52'
<i>aces of oil</i> 3' <i>ry</i> sand	38' . 90'
<i>6' 6"</i> <i>ules</i>	4' . 94'
<i>aces of oil</i> <i>mm</i> sand nodules	2' . 96'
<i>ity &amp; Granite</i> 3' <i>stone</i> nodules	
<i>oil</i> 12' <i>nd white kaolin</i>	
9' <i>in sulphides</i>	
3' <i>ules</i>	9' . 105'
<i>came up.</i>	

Government Lithographer. Perth. W. A





## 5.—The Geology of Princess Royal Harbour with reference to the occurrence of oil.

(With a Map.)

The idea of the possibility of the occurrence of oil-bearing rocks in Princess Royal Harbour appears to have been very largely based upon the fact that during the progress of dredging operations therein oil rose to the surface, and pieces of bitumen were brought up by the Government dredge.

This led to the formation of the Princess Royal Harbour Mineral and Oil Company for the purpose of prospecting for both mineral and oil ; and an application to the Department for State aid in the prosecution of the venture.

A personal inspection of about twelve days' duration was made by myself of the harbour and its surroundings, for the purpose of acquiring the necessary data at first hand.

A good deal of geological information on the vicinity of Albany appears in the various official and other reports which have appeared as far back as the year 1879 ; and as these contain some information which has an important bearing upon the question, they are somewhat freely quoted.

The geological structure of Bald Head at the entrance to King George's Sound was described by Vancouver in 1791 :—

The principal part of this country appeared to be Coral, and it would seem that its elevation above the ocean is of modern date, coral being found on the highest hills we ascended, particularly on the summit of Bald Head. In these fields of coral, seashells were in great abundance. (a)

Darwin, however, seems to have been the first to have correctly grasped the geological structure of King George's Sound :—

This settlement is situated at the south-western angle of the Australian continent. The whole country is granitic, with the constituent minerals sometimes obscurely arranged in straight or curved laminae. . . . These plutonic rocks are, in many places, intersected by trappean dykes. In one place I found ten parallel dykes ranging in an east and west line; and not far off, another set of eight dykes, composed of a different variety of trap, at right angles to the former ones. . . . The lower parts of the country are everywhere covered by a bed, following the inequalities of the surface of a honeycombed sandstone, abounding in oxides of iron.

A calcareous deposit on the summit of Bald Head, containing branched bodies, supposed by some authors to have been corals, has been celebrated by the descriptions of many distinguished voyagers. It folds round and conceals irregular hummocks of granite at the height of 600 feet above the level of the sea. It varies much in thick-

(a) *Voyage of Discovery*, Vol. I., pp. 165-6, 1801.

ness; where stratified, the beds are often inclined at high angles, even as much as at 30 degrees, and they dip in all directions. These beds are sometimes crossed by oblique and even-sided laminae. The deposit consists either of a fine white calcareous powder, in which not a trace of structure can be discovered, or of exceedingly minute rounded grains of brown, yellowish, and purplish colours, both varieties being generally, but not always, mixed with small particles of quartz, and being cemented into a more or less perfect stone. . . . Both of the above mentioned varieties of calcareous sandstone frequently alternate with, and blend into, thin layers of a hard substalagmitic rock, which, even when the stone on each side contains particles of quartz, is entirely free from them; hence we must suppose that these layers, as well as certain vein-like masses, have been formed by rain dissolving the calcareous matter and reprecipitating it. . . . Each layer probably marks a fresh surface, when the now firmly cemented particles existed as loose sand. These layers are sometimes brecciated and recemented, as if they had been broken by the slipping of the sand when salt. I did not find a single fragment of a seashell; but bleached shells of the *Helix melo*; an existing land species, abound in all the strata; and I likewise found another *Helix* and the case of an *Oniscus*.

The branches are absolutely undistinguishable in shape from the broken and upright stumps of a thicket; their roots are often uncovered and are seen to diverge on all sides; here and there a branch lies prostrate. The branches generally consist of the sandstone, rather firmer than the surrounding matter, with the central parts filled, either with friable calcareous matter, or with a substalagmitic variety; this central part is also frequently penetrated by linear crevices, sometimes though rarely containing a trace of woody matter. These calcareous branching bodies appear to have been formed by fine calcareous matter being washed into the casts, or cavities, left by the decay of branches and roots of thickets, buried under drifted sand. The whole surface of the hill is now undergoing disintegration, and hence the casts which are compact and hard are left projecting. In calcareous sand at the Cape of Good Hope I found the casts, described by Abel, quite similar to these at Bald Head; but their centres are often filled with black carbonaceous matter, not yet removed. It is not surprising that the woody matter should have been almost entirely removed from the casts on Bald Head, for it is certain that many centuries must have elapsed since the thickets were buried; at present, owing to the form and height of the narrow promontory, no sand is drifted up, and the whole surface, as I have remarked, is wearing away. We must therefore look back to a period when the land stood lower, of which the French naturalists found evidence in upraised shells of recent species, for the drifting on Bald Head of the calcareous and quartzose sand, and the consequent embedment of the vegetable remains. . . . Reflecting on the stratification of the deposit on Bald Head; on the irregularity of alternating layers of substalagmitic rock; on the uniformly-sized and rounded particles, apparently of seashells and corals; on the abundance of land shells throughout the mass, and, finally, on the absolute resemblance of the calcareous casts to the stumps, roots, and branches of that kind of vegetation, which would grow on sand hillocks, I think there can be no reasonable doubt, notwithstanding the different opinion of some authors, that a true view of their origin has been here given (a).

These observations of Darwin's, which have been quoted at length, are of importance in that they conclusively prove that the

corals of previous writers are calcified branches of trees, and the marine shells are identifiable with the recent land shells; observations which have a bearing upon the occurrence of oil in the formation.

Mr. H. Y. L. Brown, writing in August, 1872, in reference to what is evidently the same formation, stated :—

Along the coast, in a more or less broken line, on the southern and western coasts, never extending inland more than a few miles, there are hills and ridges composed of beds of calcareous grit, sandstone, and limestone, rising from below sea-level to a few hundred feet above it.

On the southern coast these occur only as patches, but on the western as an almost continuous strip, extending from Cape Leeuwin to the Murchison River and probably beyond. The presence of this formation appears to be due to the growth of coral reefs, upon which shells, sand, etc., have accumulated and become consolidated by the infiltration of water containing lime in solution. As a rule, the different layers of calcareous sandstone, limestone, etc., are horizontal, though often false bedded. They contain fossils, some of which are but little different from those now existing on the shores of the ocean surrounding this portion of the continent. (a)

And in 1892 Mr. H. P. Woodward reported :—

On the south side of Princess Royal Harbour, and from it to Torbay, a line of limestone hills forms the coastal range for a distance of about nine miles, whilst to the northward sandy and swampy flats with low ferruginous sandstone hills extend nearly as far north as Mount Barker, a distance of about 25 miles, spreading out to 15 or 16 miles in width between the Hay and Kalgan Rivers. In this large basin a bore has been put down 68 feet by Mr. Parry at Eastwood,  $7\frac{1}{2}$  miles on the railway from Albany, the property of Mr. Powell, when the following section was obtained:—

Sandy peat	..	..	..	8ft. 6in.
Ferruginous sandstone	..	..	..	1ft. 0in.
Sand and black clay	..	..	..	5ft. 6in.
Quicksand	..	..	..	5ft. 0in.
Ferruginous sandstone	..	..	..	ft. in.
Quicksand	..	..	..	30ft. 0in.
Stiff black clay	..	..	..	4ft. 0in.
Quicksand	..	..	..	10ft. 0in.
Brown coal, quicksand	..	..	..	3ft. 0in.
Total	..	..	..	67ft. 1in.

At this depth the bore most unfortunately fell in, so it still remains undetermined as to whether true coal measures do exist beneath this formation or not. The sample is of a dull sooty black colour, showing a good deal of vegetable structure. It is not highly mineralised but fairly compact, soft, friable, and soils the hand. The fracture is irregular, showing a laminated structure. It does not ignite readily, but when made red-hot it burns slowly, giving out a good deal of heat, and when ignited in a tube it gives off a small quantity of gas, tar, and water.

(a) On a Geological Exploration of that portion of the Colony of Western Australia lying Southward of the Murchison River and Westward of Esperance Bay. Perth: By Authority, 1873, p. 14.

An analysis yielded the following result:—

Water	..	..	..	..	..	6.275
Volatile matter	..	..	..	..	..	18.84
Fixed carbon	..	..	..	..	..	14.835
Ash	..	..	..	..	..	60.05

The percentage of water is low for a coal of this class, the volatile matter, consisting of luminous and non-luminous gases, is also low; so is the fixed carbon, whilst the quantity of ash is enormous. The coke was in the form of a fine sooty powder, whilst the ash was light, and of a creamy colour. It is of no commercial value. . . .

In the same report Mr. Woodward states :—

The hills along the South Coast are of two ages, those forming the main coastal range being the older. They consist of a series of lime stones and shaley sandstones dipping at an angle of 40 to 45 degrees to the north-east, or under the flat in which the boring operations have been carried on. In these outcrops no organic remains were visible but to judge from their dip, which is persistent for a distance of nine miles, they must be of considerable antiquity, as we know that very little disturbance has occurred in the Mesozoic Period.

At the south-east end of this range, and to the south of Princess Royal Harbour, the limestones are white, earthy, and contain fragments of hard cream-coloured limestone; but the sandy shales are entirely absent. Although these hills run in the same direction as those farther to the westward, they have no well defined bedding, and are probably the passage or junction beds between the Mesozoic sandstone, which outcrops all down the coast to the eastward, and the older rocks met with here. These Mesozoic sandstones make their last appearance on the side of Mount Clarence, which is on the north side of the harbour, where a sample obtained in sinking a well contained the characteristic fossils, but no fossils have yet been found in these rubbly limestones. . . . It is evident that a large basin, surrounded by granite, does exist, and that rocks, probably of Palaeozoic age, outcrop on its southern side (a). . . .

In the year 1900, a report upon boring for coal near Albany was prepared by myself, and full details given regarding the 16 bores which had been sunk in the vicinity. The deepest bore was carried down to a depth of 234ft., and in every case the floor of the older crystalline rocks upon which the beds were laid down was unequivocally reached. (b)

Princess Royal Harbour is about  $4\frac{1}{2}$  miles long in a direction of about north-west and south-east, with a width of about  $2\frac{1}{2}$  miles. The harbour itself is very shallow, and particularly so at its north-western end.

Lying to the south of the railway line, and between it and the coast, is a strip of low-lying land connecting the head of the harbour with Grassmere and Torbay Inlet.

There are very strong grounds for believing that Princess Royal Harbour and Torbay Inlet were at one time connected, and that the high ground extending from Limestone Head to Port Hughes formed

(a) General Report by the Government Geologist for the year 1892.

Perth: By Authority, 1893, pp. 3 and 4.

(b) Annual Progress Report of the Geological Survey for the year 1900.

Perth: By Authority, 1901, pp. 14-20.

elongated ridge separated from the country to the north by a more or less extent of sea water.

Several bores have been put down in this low ground, and in every case was the floor of the older crystalline rocks met with, the greatest depth being 234ft. Full details regarding these bores can be found in the Annual Progress Report of the Geological Survey for the year 1900, pp. 16-20.

The high ground on the north side of the Princess Royal harbour, including Mounts Adelaide, Clarence, Melville, and Ellinestone, is composed of granite of the type which occupies such large area to the north. This granite is traversed by greenstone dykes, some of which can be seen on the beach near the gasworks.

The high ground upon which the Quarantine Station is built is also made up of granite; this granite also is traversed by numerous dykes of greenstone, many of which may be seen on the east between Barker Bay and Mistaken Island. These dykes are pretty well all parallel, practically vertical, and have an average strike of about 101 degrees. Some of the dykes contain masses of granite, which have been caught up during the injection of the basic magma. The granite mass of the Quarantine Station extends south-east, and forms Mistaken and Seal Islands, and the rock underlying the more recent beds of Limestone Head.

On the south side of the harbour at Grave Head (Stuart's lead of Admiralty Charts) is a fairly extensive belt of granite which reaches down to sea level. This patch is separated by a comparatively thin cover of recent deposits from a much larger and more extensive area, which extends from Limekilns Point (Limeburner Point of the Admiralty Charts) to the summit of Snake Hill, 320ft. above sea level. At Limekiln Point the granite is overlaid by a thin belt of sandy limestone, which occupies a narrow strip round this portion of the beach. The limestone, which forms the summit and flanks of Snake Hill, extends southwards and forms the northern slopes of that high ridge which separates Princess Royal Harbour from the Southern Ocean. Granite was also met with in two of the bores (Nos. 1 and 2) put down in Princess Royal Harbour by the Mineral and Oil Company, at depths of 46ft. and 18ft. respectively. These two bores were put down near the north shore, not far from Melville Point (Testing Point of the Admiralty Charts). The old granitic floor was pierced at a depth of 109ft. in a bore a mile south of the Eastwood Railway Station, whilst at Torbay Junction, bottom was reached at 134ft., after passing through variable thicknesses of drift sand and clay.

The granite also makes its appearance again in great force in the high ground upon which the Trig. Station (470ft.) near Port Hughes has been erected. Stony Island, on the south coast, due west of Grove Hill and due south of Eastwood is also of granite.

These observations indicate perfectly clearly that the landlocked Princess Royal Harbour is merely a relatively shallow depression, resting upon a floor of ancient crystalline rocks. This fact is of importance in its bearing upon the possibility of mineral oil in the harbour.

From Port Hughes, at Torbay Inlet, to Limestone Head is a line of very high perpendicular limestone cliffs, which were carefully examined in two localities; these beds form most conspicuous features in the landscape, and in places are exceedingly picturesque, owing to the number of caves and caverns into which they have weathered. These beds rise to a height of nearly 700ft. above sea level. These limestones are aeolian deposits, consisting practically of shell sand, cemented in places into solid rock owing to the action of rain water.

The shell sand is converted into a limestone of sufficient hardness to ring like a bell when struck with a hammer; there are, in addition, several softer chalklike beds, which pass by almost insensible gradations into a very hard compact stone.

Landwards these aeolian deposits terminate in a more or less regular smooth bank or face, to which layer after layer is gradually added. The irregular current bedding of these deposits gives the appearance of limestones dipping at varying angles from the horizon, and apparently overlaid by nearly horizontal beds.

These aeolian deposits attain their greatest development on the sea coast to the south of Princess Royal Harbour. Isolated fragments and blocks of the chalklike limestone are occasionally dredged up in the harbour, along with pieces of drift asphaltum, etc., of extreme origin.

A very recent formation occurs at many points round the harbour, and consists of a somewhat peaty ferruginous, partly consolidated, sand "associated with the formation carrying bitumen and traces of oil." At several places there exudes from this formation a compound of iron, which, when floating on the surface of the water, shows a play of prismatic colours, very often mistaken for those produced by some oils.

A scum of this kind can very easily be distinguished from that produced by oil in that the scum from an iron compound of this kind will readily break up into irregular fragments on being stirred but if of oil it will form bands of colour.

At times there may be seen floating about Princess Royal Harbour patches of an oily substance, which have been claimed to have been seen rising from beneath the water at several portions of the harbour, and to be an indication of an oil-bearing formation beneath.



A sample of this shown to me was associated with fine coal dust, and had the characteristic odour of machine oil, such as is in use in many of the steamers frequenting the harbour.

There is nothing in the geological constitution and structure of Princess Royal Harbour to in any way indicate that the occurrence of mineral oil is probable ; whilst the wrong hypothesis as to the source of the bitumen dredged up and the oil floating about on the surface of the water, appears to have led to money being needlessly spent in boring, etc.

A. GIBB MAITLAND,  
Government Geologist.

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## 6.—Notes upon the Geological Map of the Green River District.

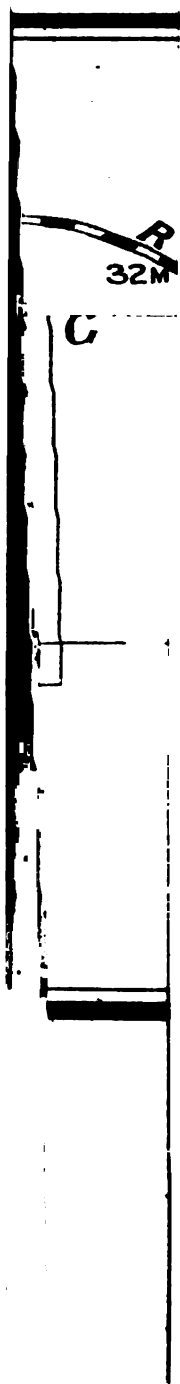
(With a Map, Plate VI. and a Geological Section Plate V.)

The area examined extends from near the Wizard P. Eradu, and includes the Minnenooka, Sandspring, and Tib areas. The distance across in a direct line is about 18 miles, the course of the river it is about 45 miles.

Granite and garnetiferous gneiss forms the river bed below Glengarry to the road crossing at Loc. 409, and extends the base of Wizard Peak and of the adjacent flat-topped Minnenooka and nearly to the Sandspring homestead, and ward to Tibraddon, and eastward from there to Wicherina about  $3\frac{1}{2}$  miles from Eradu; only three small diorite dykes seen and very few quartz reefs. These crystalline rocks attain an elevation of nearly 1,000 feet in places. In other portions of the district they are overlaid by a series of sandstones and glomerates, which are mostly horizontal, but have in places an inclination of about 4 degrees to the south. The upper 200 feet of these beds on the western escarpments of the granite have argillaceous and marly bands, which are mostly fossiliferous containing marine shells of apparently jurassic age; 250 specimens of these fossils were collected, together with fragments of corals which occur in beds below or interstratified with the beds of corals and shells.

The whole sedimentary beds vary greatly in character frequently exhibit current bedding, and are evidently shallow water deposits; some of the white sand rock or sandstones are argillaceous where this is the case there are argillaceous sandstones below. The sandstones are frequently so ferruginous as to have the appearance of an ironstone, and laterite frequently occurs on their surface. This laterite is often difficult to be distinguished from the ferruginous beds themselves. The sandstones also form the high plains occupying all the highest ground towards the north and east of the area described and beyond.

There appears to be a probability that there are two formations of different ages comprised in these sandstones, the older may be of permo-carboniferous, and the younger of jurassic age. The former was laid over the then submerged hills and valleys of the granite and gneiss rock, and may have become eroded towards the western slopes of the granite, and afterwards both were overlaid by jurassic sandstone.





The majority of the fossiliferous horizons occur in the uppermost beds and are often covered directly by laterite; but fossils appear to occur also over 100 feet below these, as in the valley above the Tibraddon homestead.

The accompanying general section (Plate VI.), which I have drawn, shows the extent of the information at present obtainable, while the map (Plate V.) shows the area coloured geologically in as much detail as the month at my disposal permitted.

No shale or coal beds were seen, but these may possibly exist at a lower depth than has yet been reached in the Greenough area by boring.

The brackish and saline character of the pools of that portion of the Greenough River below Beetalyianna Point appears to be due to the saline sandstone which occur below that point. A sample of water from one of the pools that was in process of being dried up, was obtained for the Analyst's examination. Springs are fairly plentiful in the granite area and afford good potable water. Good supplies of water have also been obtained by wells sunk 30 to 40 feet into the sandstone at Sandspring; at the latter place an excellent spring also occurs in the sandstone at that homestead, but elsewhere the well water is mostly brackish.

W. D. CAMPBELL,  
Assistant Geologist.

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NOTE.—For a list of the Champion Bay Jurassic Fossils, see page 60.

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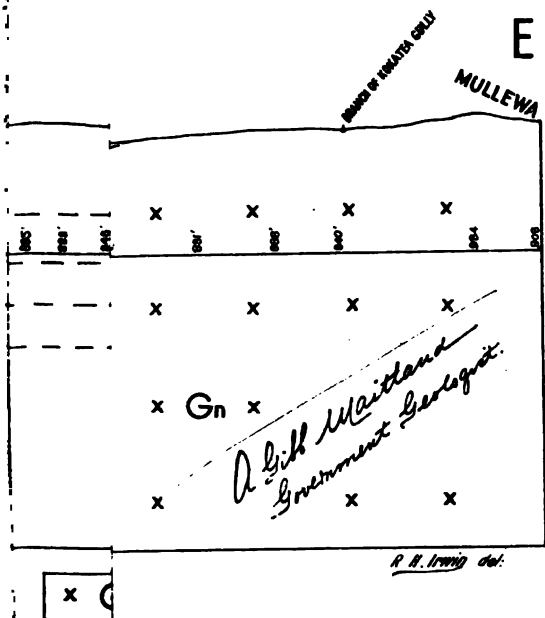
## Appendix I.

### LIST OF SPECIMENS IN THE GEOLOGICAL SURVEY MUSEUM FROM THE GREENOUGH RIVER.

Reg.  
No.

- 6661.—Diorite, 1 mile south of Tibbraddon Homestead,  
crossing gully, Microscopic Section made ... 3 specimens
- 6662.—Diorite, Loc. 492, in river bed below road crossing ... several small  
specimens
- 6663.—Aphanitic Diorite,  $\frac{1}{4}$ -mile north of Quarry Hill and  
1 mile south of Sandspring Homestead ... 1 specimen
- 6664.—Granite, adjoining diorite dyke specimen 6661 ... 1 specimen
- 6665.—Granite, 1 mile south of Tibbraddon Homestead, in  
gully ... 1 specimen
- 6666.—Granite, Wicherina Spring ... 2 specimens
- 6667.—Graphic Granite, centre of Loc. 1236, Snake Farm ... 3 specimens
- 6668.—Micaceous Sandstone, near Loc. 492 ... 1 specimen
- 6669.—White Saline Sandstone, upper part of cleft near  
Photo. 259 ... 3 specimens
- 6670.—Sandstone, 2 chains north-east of Photo. 259 ... 3 specimens
- 6671.—Argillaceous bed in river cliff below specimen 6669 ... 1 specimen
- 6672.—Ferruginous Sandstone, near Loc. 1236 ... 1 specimen
- 6673.—Stratified kaolinized granitic material ... 1 specimen
- 6674.—White Sandstone, near Loc. 1236, Snake Farm ... 1 specimen
- 6675.—Fibrously crystalline siliceous bed, top of hill, west of  
Loc. 492 ... 1 specimen

BULLETIN NO 26 PLATE VI.







## 7.—Recent Advances in the Knowledge of the Geology of Western Australia.

(Being the **PRESIDENTIAL ADDRESS** by A. GIBB MAITLAND, F.G.S., Government Geologist of Western Australia, and formerly of the Geological Survey of Queensland, delivered in Adelaide before Section C of the Australasian Association for the Advancement of Science, on the 8th of January, 1907.)

My first duty in assuming the position of the Presidentship of the section of Geology is to express to you my deep sense of gratitude for your confidence in my devotion to the welfare of our science implied in the election of one who, owing to the exigencies of official life, has had few opportunities during the last 19 years of becoming personally acquainted with the majority of the "Brethren of the Hammer" in Australia. The honour, however, is enhanced by the fact that in addressing the members of this section of the Association in Adelaide, I am speaking in the capital of a State which has contributed—in the persons of Messrs. H. Y. L. Brown and H. P. Woodward—so much to the progress of official geological research in Western Australia.

The civilising value of scientific investigation, such as is evidenced by a gathering of this kind, where the "hammerers" from the West meet those from East, upon common ground, for the purpose of discussing, consolidating, and recording the work of the past, must tend to link all parts of this continent together, and time perhaps will show that it may fall to the lot of the Australian men of science to materially assist in the solution of the problem of preserving those harmonious relationships and the strengthening of those ties which are so severely taxing the combined resources of political diplomacy.

It is, I believe, customary for the occupant of the Presidential chair to offer a few observations on some special department of the science which seems in his opinion worthy of attention, and I am therefore unwilling to depart from what must be regarded as traditional usage. On looking over the list of subjects reviewed by my predecessors in this chair, and the contributions of the different members read before this Section, I find few dealing with those portions of Australasia with which I am personally familiar, viz. :—Queensland, British New Guinea, and Western Australia.

After due consideration, therefore, I have chosen to invite your attention for an academic hour to a succinct account of the recent advances in our knowledge of the geology of the Western portion of this Continent, to the investigation of which my attention has been more immediately directed during the last decade.

In a broad and general way the geology of Western Australia offers many interesting points of analogy with that of South Africa and India.

In the present condition of our knowledge of the geology of the State, it is almost impossible to deal systematically with the various formations as a whole, for, owing to a variety of causes, geological inquiry up to the present has consisted merely of a series of unconnected observations, to the co-ordination of which we must look to the future ; nevertheless our observations have been so widely extended as to permit of certain broad generalisations.

Geologically the rocks of the State may, for the purpose of this address, be divided into three distinct groups, viz. :—

- (I.) The crystalline, schistose, and metamorphic rocks, a group the members of which have certain features in common, occupy definite areas, and various lines of inquiry point to being of considerable geological antiquity, possibly of Archæan Age, though in the present condition of our knowledge I prefer to adopt the term Pre-Cambrian.
- (II.) The sedimentary rocks which extend with many blanks from the Lower Cambrian to the most Recent ; and
- (III.) The volcanic rocks which are so largely developed in the northern portion of this State.

#### *I.—The Crystalline Schists and the Metamorphic Rocks.*

The Pre-Cambrian crystalline schists, and metamorphic rocks constitute the principal mineral region of Western Australia, and so far as is at present known, the area occupied by these venerable beds is about two-thirds of the total superficial extent of the State, which is 975,920 square miles. As our knowledge advances, however, this estimate of the area occupied by the Pre-Cambrian rocks may be subject to some modification.

There are probably few parts of this continent which can boast of a finer development of these older rocks than Western Australia, and perhaps no more promising field can be found for their investigation.

Considerable interest in connection with these rocks centres, so far as petrographical questions are concerned, in the translation of both the igneous and sedimentary formations into crystalline schists. Observations in the field point to the possibility of the mechanical movements to which the rocks have been subjected having modified or obliterated structural features previously impressed upon them, and that they may contain formations belonging to different geological systems. Sections in the Nullagine District show those beds to be made up of cleaved conglomerates some of whose pebbles consist of a pre-existing conglomerate from an earlier

series, of which no trace has yet been found. With a possible exception alluded to later on, it is important to note that this ancient metamorphosed sedimentary series, so abundantly represented in Western Australia, has yielded no fossils as yet.

If perhaps I dwell at a somewhat greater length upon these older rocks, it is that their economic importance has necessitated the attention of the Geological Survey, being up to the present, principally devoted to their investigation rather than to that of the strata lying unconformably above them.

Time will hardly admit, though there is the inclination, of trespassing upon your time by affecting comparisons with the geology of similar areas of Pre-Cambrian rocks in other countries, nor discussing many of those theoretical questions arising out of the data which have been massed.

These older rocks have been studied in more or less detail in different localities throughout the State, distributed over fourteen degrees of latitude. They consist of rocks of very different types, many of them are in a crystalline condition, and form coarse crystalline schists and gneiss, which differ but little from granite and other rocks of like origin, as well as basic rocks, which have been more or less crushed, foliated, and completely converted into greenstone schists.

A very important feature of these basic schists is the presence among them of unfoliated rocks which sometimes occur in the form of lenticular belts of considerable extent, diabase, dolerite, diorite, epidiorite, pyroxenite, porphyrite, amphibolite, etc.

In some localities these basic rocks can be seen passing by scarcely perceptible gradations into hornblende schists, while in others are bands of magnetite schist, in the centre of some of which are large phacoidal-shaped masses of greenstone occurring in such a way as to indicate that the margins only of the masses have been ground down into schists.

Some of these older rocks are of sedimentary origin, and are practically unaltered; others are quartz, mica schist, and granulites, whilst these represent the two extremes there are intermediate forms which link them together. The less altered members of these older rocks make their appearance in many portions of the State; the rocks consist of a great variety of types of indurated slates, quartzites, and conglomerates, together with igneous rocks, some of which there are very good grounds for believing to have been originally lavas and ashes.

Many of these old crystalline rocks have been so altered as to possess characters which cannot be looked upon as original because many of them have lost, not only their individuality, but also their geological identities.

A remarkable and very noticeable feature of these older rocks in most localities in which they have been examined is those bands of laminated quartzites and jaspers (which often contain oxide of iron to such an extent as to warrant their being classed as iron ores). These extend as roughly parallel bands, sometimes several miles in length, in the form of attenuated lenses which, owing to their serrated ridges stand out in bold relief, thus acquiring a conspicuousness perhaps out of all proportion to their real stratigraphical importance. These beds vary from almost pure quartz through varieties of banded hornstone, jaspers of great beauty, to almost pure hematite.

In certain localities these jaspideous beds present a very brilliant appearance, due to the interlamination of red, white, and dark-coloured bands with intermediate varieties, the difference of colour being due to the occurrence of iron in the form of either limonite, haematite, or magnetite.

These bands are often intersected by numerous faults, which, in some districts, are of considerable economic importance, for it is along these fault lines, generally at right angles to the strike of the quartzites, that rich shoots of gold often occur. In some cases these iron-bearing jaspers attain a very great thickness, over 1,000ft., and have been very much plicated and contorted, whilst in places they have been faulted in a direction parallel to the strike. The fault fissures being often filled with a fault breccia of jasper recemented by secondary chalcedonic silica. In all cases these jaspers and quartzites are vertical or inclined at high angles. In many localities these quartzites and jaspers contain magnetite in such quantities to render the use of a compass in the vicinity almost impossible. These beds have been styled quartzites, a term implying that they are sedimentary; they are, however, not of detrital origin, numerous sections in many of the fields show them passing by almost insensible gradations into the enclosing basic schists, the whole appearance suggesting a gradual replacement of the original rock along lines of maximum compression, a foliation by silicification, in other words they represent a case of metasomatism on an extensive scale.

It may be of interest to note that these beds invariably occur in the basic schists, in intimate association with auriferous quartz reefs, and are at times themselves auriferous. In order that the present confusion arising through the want of a name to distinguish infiltration or metasomatic quartzites from indurated sandstone may be obviated, I hope some one may be able to suggest a convenient means of escape from possible civil war between the field man and the laboratory man to which the present unsatisfactory system of nomenclature rather tends.

In 1905 the various divisions of these older crystalline rocks as developed on the Norseman Goldfield, were carefully mapped

and investigated, the salient features of which may be briefly summarised. The staple formation consists essentially of a series of highly inclined sedimentary rocks estimated to reach a thickness, making due allowance for repetition by folding, of about 800ft.

No argillaceous slates appear to occur in the Norseman district, though associated with the metamorphic sedimentary rocks is a bed of very coarse conglomerate. Some of these ancient sedimentary rocks appear to have been permeated by secondary silica and oxide of iron to such an extent as to form very conspicuous bands of laminated quartzites and jaspers, which make a pronounced feature of the field. Associated with the metamorphic sedimentary beds of Norseman are a series of interbedded igneous rocks, some of which are distinctly amygdaloid, and although most of their original characters have been almost entirely obliterated, there seems every reason to believe them to be ancient lava flows, which were poured out at practically the same geological period as the associated sediments. In addition to these undoubted lava flows, there are a series of diorites and epidiorites, which seem to be interbedded with the former in such a way as to suggest the possibility of their being intrusive sills and dykes. These igneous rocks have been subjected to considerable dynamical alteration, and in places appear as mica and chloride schists.

Another very important feature in the geological structure of Norseman is the occurrence of a large number of quartz porphyry dykes which traverse the eastern portion of the field in a general north-west and south-east direction. These acidic dykes vary much in appearance, colour, and texture, the crystallisation in some cases being such that the rocks look not unlike somewhat fine-grained indurated sandstone. These acidic dykes contain crystals of pyrites, and are occasionally slightly auriferous. These dykes in all probability form the apophyses of that large granite mass which lies to the east of Norseman. There are, in addition, a few isolated veins and dykes of dolerite, one of which is seen intersecting the quartz reef in one of the mines. The newest igneous rock on the field is the intrusive norite, which forms an east and west range, varying from a mile to half a mile wide, and which extends in an uninterrupted line to Mount Norcott, about twelve miles to the east, and for a considerable distance both east and west.

The earliest observer in this district, Mr. S. Goczel, indicates on his geological sketch map of the Auriferous Region of Western Australia the greenstones and allies of Norseman as being of Paleozoic Age, whilst the micaceous and talcose schists of the same district are referred to the Archæan.

The crystalline rocks of the type just described may be traced as far as the Kalgoorlie Goldfield, the wealth of which, coupled with the skill which directs both the mining and the metallurgical opera-

tions, have raised Western Australia to the front rank of mining countries in the British Empire.

As is well known, the productive area comprises a relatively small block of ground, which, by reason of the richness of the lodes by which it is riddled, has become known throughout the world as the "Golden Mile."

This area includes the well-known "Great Boulder," "Ivanhoe," "Horseshoe," "Perseverance," "Oroya-Brownhill," "Associated," and "Lake View Consols" mines. The deepest shaft at present is the Great Boulder, which has reached over 2,000ft., while the greatest depth to which the lodes have been followed is over 2,000ft. The country laid open by mining for investigation as judged by the number of drives and crosscuts amounts to several miles, whilst the rocks have been riddled with bore holes in all directions and angles, thus affording opportunities for the scientific study of many of the rocks in critical localities, and in their relation to the ore deposits, such as are hardly found in any other single mining field of the globe.

The geological structure of Kalgoorlie is not of that extreme simplicity which at one time had been anticipated. The staple formation consists as at Norseman, largely of certain schistose rocks, some of which are distinctly of sedimentary origin. The sedimentary beds are represented by rocks, which range from soft shales to jasperoid slates, grits to flinty quartzite, fine conglomerates or breccias to fairly coarse boulder conglomerate.

In intimate association with the sedimentary beds are a series of hornblendic rocks, but whether these occur in the form of lava flows or are intrusive is as yet by no means clear.

There are, however, in addition to these certain undoubtedly intrusive igneous rocks, sodafelsites and porphyrite.

Most of the rocks of Kalgoorlie appear to have been highly altered by dynamical causes, with an accompanying recrystallisation of their constituents; many of them have been carefully analysed and microscopically investigated in the laboratory of the Geological Survey and the results made available. Time will not admit of detailed reference being made to the deductions to be drawn from these investigations, beyond the fact that the "lode formations," for which the field is famed, consist of a series of almost vertical banded schists of lenticular habit, and apparently owe their origin to the dynamo-metamorphism of a plagioclase-augite rock. Many of these ore lenses are of great length, and in some cases of considerable breadth; at times however, the lateral continuity of the lenses is interrupted by overthrust and normal faults of very variable downthrow.

For a systematic study of the metasomatic history of the auriferous deposits, leading as such must do to the discovery of

facts which will materially guide scientific mining, Kalgoorlie offers few, if any, rivals in Australia.

So far as observations have, however, at present been carried there do not appear to be any scientific reasons for believing that the mines of Kalgoorlie have by any means reached the limits of ore deposition, or that the lodes will not prove as a whole productive in depth.

The Pilbara district (lat. 21 degrees) affords better and more continuous sections than are generally to be met with in any of the other districts which have yet been examined; it thus reveals geological structures which are not to be found in the more southerly districts, and on this account serve to throw light upon obscure points in connection with the geology of other districts. These sections furnish very important evidence regarding the terrestrial movements to which these older rocks have been subjected. The Pilbara district contains very large areas of granite, granodiorite and gneiss, which, however, are not the oldest rocks. In every case where their relation to the schists can be observed along the margin, it is seen that these granites are everywhere intrusive, having gradually eaten its way into and partially absorbed them, and several sections may be noticed in which the granite sends out tongues and veins into them. One of the best localities in which the relation of the granite to the metamorphic rocks is at the Wodgina tinfield, which is situated on the headwaters of the Turner River about 24 miles from Port Hedland. The districts consist of a series of metamorphic sedimentary and bedded igneous rocks skirting the margin of an extensive granite mass, several hundred square miles in extent. These sedimentary auriferous rocks are pierced by a multitude of granite veins which in this district are of considerable economic importance by reason of the fact that they form matrices of tin and tantalite, for which Wodgina is noted. Near the tinfield is an instructive section showing a much older intrusive granite rock, which has been invaded by the much newer (though still old) tin-bearing granite. These acidic veins are made up of a coarse-grained rock composed of mica, quartz, felspar, and now and then tourmaline, and may be described as pegmatite, using the term in the sense in which it was applied by Delesse for any coarse-grained granitic rock containing mica, quartz, felspar, and tourmaline. No reference to these old granitic rocks would be complete without some mention being made of the large ice-like quartz reefs, which stand up to considerable altitudes above the surface like a wall, and which can in some cases be traced across country, with more or less interruption, for miles. They may be described as veins or dykes of pure silica, in some of the mine workings in two fields veins of this character are to be seen cutting across the auriferous quartz reefs. The question as to the relationship of these acid intrusive dykes of the type just mentioned and these quartz reefs has recently been attracting con-

siderable attention, and there is a growing tendency to associate some quartz reefs genetically with pegmatite granite veins. In the Coolgardie Goldfield quartz reefs are often intimately associated with acidic dykes, and in some cases the latter gradually pass into pure quartz at their extremities. These acid dykes can be seen to pass by imperceptible gradations into the main mass of the granite at Coolgardie. Similar instances have been noticed in the Wodgina neighbourhood, and doubtless there are numerous other instances, but possibly they may have been overlooked, and their significance unappreciated.

Now a granite mass during the process of cooling gives rise to more acid pegmatite veins, and by further elimination of the bases pure quartz veins may result.

Various intermediate stages between granite and quartz veins have been noticed in Western Australia, and it is more than likely that many quartz veins are very probably intrusive rocks directly secreted from a cooling granite magma. Many pegmatitic granite veins contain tourmaline crystals as one of their essential constituents and many pure quartz veins in Western Australia contain tourmaline also.

Up to the present time, however, no observations have been made in this State with the object of discovering whether there are any of those structural and mineral changes induced in the enclosing rocks by the introduction of the quartz such as may often be observed consequent upon the injection of granitic veins. Observations upon this head, which are much to be desired, would have considerable scientific and even more important economic value.

In the southern portion of the State, the Darling Range, the Northampton District, etc., this fundamental complex is pierced by a much later series of basic dykes, where they sometimes preserve their dyke-like features across country without a break for miles. In the North-West district, however, they occur on a scale of magnificence as yet unknown in any other portion of Western Australia. Owing to the marked features which many of them exhibit these dykes can be readily followed across country, and in certain localities they are of considerable value in working out the details of the geological structures. A feature of significance is the faulting these later dykes have undergone since their injection and consolidation. In the Warrawoona field, an important North-West mining camp, these basic dykes traverse the centre of the auriferous zone almost at right angles to its general strike. The regular continuity of the system of dykes (which extend across country for 30 or 40 miles) has been interrupted in the vicinity of their intersection with the auriferous series, and they have undergone considerable movement since their injection. The peculiar dislocation and apparent displacement in short segments are probably due to a development of step-faulting in a manner not as yet



fully understood. The dykes are apparently cut into curved and distorted segments and displaced along more or less vertical planes which have a general tendency to shift the separate portions bit by bit, in one direction, the dykes being dragged to the north-west of their course.

A very important feature in the geology of the Pilbara District is the evidence of great earth movements that affected the district.

In the neighbourhood of the picturesque Doolena Gorge, on the Coongan River, very impressive evidence of a powerful rupturing of the crust is to be seen, represented *inter alia*, by a line of dislocation, which has been proved to extend for nearly 100 miles. The large quartz reefs to which allusion has just been made are seen to be abruptly cut off by this powerful fault, which presents a steep vertical escarpment (unscaleable in places) often over 150ft. in height. At some distance north of this main fault an instance was observed (on the eastern bank of the Strelley River) of one of these large reefs, being not actually truncated, though subjected to deflection by a powerful thrust, exerted in a direction approximately parallel to its strike. In this instance the compression has been so great that this very reef, which is about 30ft. thick, was reduced to six to 10 inches, whilst the horizontal displacement reached about 100ft.

The quartz reefs of the district also afford evidence of overthrusting, contortion, etc., and many of them present features which seem to indicate that they have been wrenched apart by movement along shear planes. A very important instance of this is to be seen at the mining camp of Warrawoona, where a line of reef of a peculiar type traverses the field along a powerful dislocation, which has been followed for two and a half miles.

This dislocation occurs along a persistent reef, portions of which have been torn apart and shifted in segments, producing the peculiar kidney or damper-shaped lenses of quartz, which vary from a few inches to a foot or so in width. The interval between each lens of quartz fluctuates within very wide limits.

The walls of the country enclosing these lenses are scored with striae in the direction of the movement in a vertical direction, and the faces of the striations are often coated with fine films of gold. The abnormal richness, nearly 3ozs. per ton, of this type of auriferous reef has resulted in its being extensively prospected almost along the whole length, hence abundant opportunities are afforded of investigating its peculiarities, both on the surface and below ground.

The ancient sedimentary beds, which consist of highly siliceous rocks, dipping at varying angles to the north and east, consist of fine-grained flaggy quartzites, conglomerates, and quartz schist.

Some of the conglomerates still retain traces of their original character, though in others most of the pebbles have been flattened out and stretched almost beyond recognition.

The oldest series of basic dykes, by which they are traversed, have also been crushed and sheared, and are now represented by bands of schistose greenstones. The rocks are also intersected by certain other acidic dykes now represented by quartz-sericite schist, which may have originally been porphyries. One example from Warrawoona is a quartz sericite schist with "eyes" of a fairly soft mineral, originally a potash feldspar, around which the fine foliation of the matrix sweeps in very graceful curves. When submitted to microscopic examination it is found that these porphyritic crystals present that peculiar peripheral granulation so characteristic of crystals and fragments which have been subject to intense crushing.

All the features, both of the rocks and the reefs, coupled with other evidence, clearly indicate the presence of a number of overthrust and normal faults, and point to a series of movements along lines parallel to that of the main trend of the dominant structural features of the district, which is north-west and south-east. The disruption of the newest series of basic dykes to which reference has been previously made, indicates that the enormous terrestrial stresses and strains continued in the same locality over a wide interval of geological time.

Traces of life may perhaps have existed in these old rocks of the north-west. Amongst the quartz schists which form the lofty serrated summit of the main axis of Warrawoona is a bed which here and there contains what at first glance appears to be fossil wood.

A characteristic specimen of this silicified wood (?) has a length of about  $4\frac{1}{2}$  inches; cross-sections of it are ellipsoidal in shape, the major axis being about  $\frac{3}{4}$  and the minor axis about  $\frac{5}{8}$  of an inch in length.

Microscopical sections, both transverse and longitudinal, were prepared and submitted along with the specimens to Mr. Etheridge, of the Australian Museum, who, however, was unable to detect any trace of organic structure in them. It is, however, quite possible that some form of organic life existed at the time these beds were deposited, and that the marked changes which they have undergone obliterated all traces of organic structure.

## *II.—The Sedimentary Rocks.*

The sedimentary rocks, etc., include the whole of the beds which lie between the ancient crystalline rocks and the more recent strata. In spite, however, of the extensive area occupied by the complex of crystalline schists, Cambrian fossils have been as yet noticed from only one locality in the far North of Western Australia.

Mr. E. T. Hardman, of the Geological Survey of Ireland, was the pioneer geological observer in the far North of Western Australia, and his researches carried out in the years 1883 and 1884 laid the foundation of our knowledge of the geology of the Kimberley District. This observer, however, obtained fossils from some limestones which have been referred to the Cambrian.

In 1891 Mr. H. P. Woodward made an extensive examination of the Kimberley District, and added considerably to the observations of Mr. Hardman.

Ten years later, in 1901, in company with Mr. Chas. G. Gibson, Assistant Geologist, I made a series of investigations in the King Leopold Plateau when searching for a reputed goldfield on the Carson River, between the 15th and 16th degrees of latitude.

In the latter part of 1905, and the early months of 1906, Dr. Jack visited Kimberley for the purpose of inquiring into the possibility of artesian water being obtained in the district.

Mr. Woodward revisited Kimberley in the winter of 1906, and examined the country between Mount Broome and the coast on the west, in the vicinity of Collier Bay, and obtained *inter alia* a trilobite from a dun-buff coloured limestone. The trilobite, which has just been submitted to Mr. Etheridge, appears to very closely resemble *Olenellus*.

Mr. Woodward describes these limestone beds as dipping at angles varying from 12 to 23 degrees to the south-west. The basal beds, consisting of limestone and conglomerate, contain fragments and boulders of the schistose and granitic rocks which unconformably underlie them. This observation is of importance in that, with the specific determination of the fossils he collected, light may be expected to be shed upon the age of the crystalline schists.

We thus have a good many details regarding the geology of this far north region, though as our knowledge has advanced it cannot be said that the tangled skein has yet been unravelled.

In the course of his investigations, Mr. Hardman gathered a suite of fossils which were critically examined by Mr. R. Etheridge and Mr. W. H. Foord and Dr. Henry Woodward.

Among the *dissecta membra* were the head and spine of a trilobite belonging to the characteristic Cambrian family, *Olenellus Forresti* and numerous pteropods, *Salterella Hardmani*, from a locality which, unfortunately, cannot now be identified. The discovery of the locality from which *Olenellus* was obtained by Mr. Hardman may be expected to go a long way towards setting at rest much that is at present puzzling regarding the geology of Kimberley.

Dr. Jack, writing in February of 1906, regarding the locality of *Olenellus Forresti*, says:—

The fossils described by Mr. Foord in his Notes on the Palæontology of Western Australia (Geol. Mag., March and April, 1890),

were collected by Hardman in 1883, and presented by him to the British Museum in 1886. Hardman's trip of 1883, described in his first report (1884), extended from Derby to the Leopold Range. Hardman's label on the trilobite in question was:—"River South of Base-line."

There are two base-lines on Hardman's maps: (F9-EB) at Mt. Campbell (Lat. 18.13) (Long. 125.30), and the other (WE-EB) at the Hardman Range (Lat. 17.40) (Long. 128.50). If the *Olenellus* was collected in 1883, the base-line referred to must have been F9-EB since Hardman could not, in 1883, have mentioned a line which was not laid down till 1884. On the other hand, there is no river "South of Base-line" F9-EB within the limits of Hardman's work, unless Christmas Creek be meant.

There is a "river" (Hardman, in Irish fashion, called all small watercourses "rivers") viz.: the Turner, south of Base-line WE-EB. It washes the south-west side of the Hardman Range, but a good deal farther from the range than Hardman's map gives it. The Base-line WE-EB could only be the one referred to on the supposition that Foord's information as to the date of the discovery was erroneous—that "1883" should read "1884."

But the limestone indicated in this case is classed by Hardman as the lower member of his Carboniferous formation, and I saw what is, no doubt, its continuation resting on a considerable thickness of beds of basalt, which lie on the upturned "Devonian" of the Albert Edward Range."

*Olenellus* is Cambrian.

Altogether, we are confronted by so many contradictory conditions that I am inclined to conclude that the fossil must be ignored as having come from a locality unidentifiable.

Despite the fact of poor localisation of Mr. Hardman's fossils, it may, I think, be taken for granted that Cambrian beds do occur somewhere in Kimberley about south latitude 18 degrees. The recent discovery of *Olenellus* and *Salterella* in the limestones of the Daly River, in the northern territory, by Messrs Brown and Basedow, is of considerable geological importance, indicating a somewhat wide distribution of Cambrian strata, and makes the solution of the Hardman puzzle almost imperative, and more especially so in the light of Mr. Woodward's recent discovery in the Napier Range.

By far the largest area of the Kimberley division is occupied by a formation which extends from Mount Hopeless, near Collier Bay via Mounts Hart, Broome, the Mueller, Saw, and Deception Ranges, Goose Hill, near Wyndham, to the South Australian border. These beds, which rest with a violent unconformity upon the crystalline schists, were provisionally referred by Mr. Hardman to the Devonian. Considerable confusion has arisen, as has recently been pointed out by Dr. Jack in a report on the Kimberley district now going through the press, in consequence of a discrepancy between the first and second reports of Mr. Hardman, in which he describes what recent observations have shown to be the same formation, first as Cambro-Silurian, or Cambrian, and later as Devonian.

These Devonian beds of Kimberley have yielded the following fossils : *Atrypa reticularis*, *Rhynchonella pugnus*, an *Orthoceras*, and two species of *Goniatites* and *Spirifera*.

A feature of interest and importance in connection with these beds is the evidence they afford of widespread contemporaneous volcanic activity. This was first noticed by Mr. E. T. Hardman in 1883 and 1884, who describes contemporaneous dolerites, volcanic breccias and tuffs. It has been suggested that some of the igneous rocks occur in the form of intrusive laccolites.

In the year 1901, Mr. Gibson and I had abundant opportunities of investigating these beds during six months spent in the exploration of what may be called the King Leopold Plateau. Our observations extended from Wyndham to Mount Hart, near Collier Bay; the Prince Regent and Glenelg Valleys—rendered almost classical by the researches of Sir George (then Lieutenant) Grey, more than 70 years ago—and as far north as Admiralty Gulf. The result of the investigations indicated that the staple formation was made up of a series of quartzites, sandstones, fine conglomerates and shales disposed in a series of broad anticlinal folds. These beds extend as one continuous formation from Mt. Cockburn to Mount Hart, a prominent summit on the King Leopold Range. Associated with the quartzites, etc., are a series of bedded and intrusive igneous rocks, the prevailing types being andesite, dolerite, and diabase. The individual characters of the different beds naturally present a large amount of variation; the rocks are sometimes amygdaloidal, and contain nodules of zeolites and agates. Beds of volcanic ash and breccia are common in certain localities.

In certain isolated portions of the district excellent sections are exposed, showing the intrusive nature of some of the igneous rocks; the sandstones are sometimes altered into hard compact quartzite, portions of which have been caught up in the body of the igneous rock. Other sections indicate quite clearly that the igneous rocks have, in some cases, found an easy passage along the bedding planes of the sedimentary rocks and evidently occur in the form of sills.

The lavas are traversed by almost vertical dykes of epidosite, which are traceable across country for long distances, whilst both the sedimentary and the igneous rocks are intersected by numerous segregation veins of quartz, some of considerable size and horizontal extent.

Mr. Hardman noticed during his explorations in 1883-4 the association of fossils of carboniferous affinities, with those characteristic of the Devonian rocks in the Kimberley beds. Dr. Jack noticed in 1906 a similar association of Devonian and Carboniferous fauna from the beds near Mount Pierre, and makes mention of the carboniferous limestone region, consisting partly of limestones of an older date, and remarks that either there are in the Mount Pierre

region separable carboniferous and Devonian strata, or the same strata contain a Devonian-carboniferous fauna. It is possible that this apparent admixture of Devonian and carboniferous fossils may have been brought about by post-carboniferous orogenic movements of which there is abundant evidence in different portions of the State.

Three field seasons spent by myself in the Pilbara Goldfield, situated in latitude 21 degrees south, afforded an excellent opportunity for examining a formation consisting of sandstones, grits, conglomerates, and limestones, some of which are magnesian, together with a series of lavas, ashes, and agglomerates of as yet unascertained thickness. In its lithological characters, its behaviour and general physical aspect it bears a very strong resemblance to the quartzites, etc., of the King Leopold Plateau, to which reference has just been made.

This formation, which has been designated the Nullagine series, has a very wide distribution in the North-West, and the associated volcanic beds occupy a large area of country in the southern portion of the district. The series, which presents a plateau-like appearance, certain of the harder beds standing out in bold relief, presenting mural faces at different levels, plays a very important part in the geology of the North-West, in addition to being of some economic value by reason of the fact that the basal conglomerate of the series has been worked for the gold it contains in two widely separated localities, viz :—Nullagine and Just-in-time.

The Nullagine beds have been followed from the Oakover River across the upper reaches of the Nullagine, Coongan, and Shaw Rivers, as far as the western boundary of the Pilbara Goldfields on the Yule River, near Cangan Pool, from which locality they can be followed without a break to the vicinity of Roebourne. The same series constitutes the Hamersley Range, which contains Mount Bruce, the highest summit in the State. The Nullagine beds are probably continuous as far south as the Ashburton River, where both flanks of the valley are formed by extensive beds of magnesian limestone, which may be continuous with those which I observed in 1905 in the recesses of the Hamersley Range.

Regarding the southern extension of the Nullagine series it may be noted that in a deep bore put down by the Government at Onslow, near the mouth of the Ashburton River, volcanic rocks identical with those in the former district were met with. It may thus be that these strata were pierced in the lower portion of the Onslow bore.

Undoubted Permo-carboniferous rocks are known to occupy a large area of country in the watersheds of the Gascoyne, the Minilya, and the Lyndon Rivers, hence the examination at present being undertaken of the country lying between Onslow and Lyndon should afford some valuable information as to the mutual relations of the

Permo-carboniferous and the Nullagine beds. So far as observations have at present been carried there seems to be a gradually ascending geological series as we proceed southwards. What I am inclined to regard as outliers of the Nullagine series occur in the Murchison Goldfield, near south Latitude 27 degrees. In 1904 Mr. Gibson mapped a considerable portion of the auriferous belt of the Murchison, and described a series of fine-grained volcanic ashes, lying almost horizontally on the granite of Mount Yagahong, about two miles south of the townsite of Gabanintha. The beds have evidently a wide extent in the Murchison. At the town of Cue, some distance to the south of Gabanintha, there is a horizontal dolerite sheet capping what is known as Cue Hill, and some little distance to the west on the lower ground are a few outliers of quartzite on a lower horizon. These quartzites evidently form part of a much more extensive formation of which they are but remnants left. There is very little doubt that these beds form part of the same series as the volcanic ashes at Gabanintha.

The igneous rocks associated with the series consist generally of acidic lavas. The great mass of the rocks consist of separate lava flows, each of no great thickness; some of the lavas are distinctly amygdaloidal, the cavities being filled with chalcedony.

Some of the finer-grained ashy beds differ very little in general appearance from many of the banded lavas with which they are associated.

Undoubted volcanic focii, from which these lavas emanated, occur in many parts of the districts, though they have been extinct long enough to allow the process of weathering to reduce them to mere stumps. There are also several acidic dykes which pierce both the sedimentary and the volcanic rocks, and these in all probability represent but another phase of that extraordinary volcanic activity which occurred in the northern portion of Western Australia during the Devonian period.

Considerable interest attaches to the Nullagine series by reason of the nature of the boulder beds at the base of the formation, for two important scientific reasons, viz. :—(a.) the occurrence of flattened and striated pebbles to which a glacial origin has been assigned; and (b.) the nature of the gold and iron ore in the conglomerate.

The basal conglomerate of the series is made up of rounded, ellipsoidal, or subangular fragments of the older underlying series. Many of these often include pieces which reach a length of three or four feet. Some portions of the conglomerate contain flattened and striated pebbles of fine-grained sandstone and sandy shales, identical in character with those constituting the underlying strata. To these striated pebbles a glacial origin has been assigned by the late Mr. S. J. Becher, and subsequently by Professor David. The pebbles, however, seem to have had their striation induced

prior to their taking part in the formation of the Nullagine series. The beds upon which the series rest, and to the denudation of which the boulders owe their origin, having, as has already been shown, been subject to intense mechanical deformation, it would only be natural to find some slickensided fragments and pebbles in newer rocks. Earth movements have caused the Nullagine beds to be thrown into a series of undulatory folds, but the deformation thus induced has not been of sufficient intensity to cause any striation of the Component pebbles.

Such mining operations as have been carried out in the auriferous conglomerate have been, up to the present, confined to relatively shallow depths along the outcrop; the conglomerate is in part marked by the presence of large quantities of iron pyrites and its oxidation products. In the inoxidised portion the pyrites occur both as crystals, grains, and rounded or pebble-like forms. A certain interest attaches to the occurrence of these rounded pebbles and pellets of auriferous pyrites and hematite on account of the fact that they have been regarded as owing their shape to attrition, and that the gold and the iron are detrital, having been deposited with the pebbles of the conglomerate, as the result of all disintegration of the underlying auriferous rocks. The evidence respecting the origin of the gold in the Nullagine conglomerates indicates that it is a secondary and not an original constituent, and further, that the primary source of the gold is the quartz reefs which occur in the underlying formation.

From the known occurrence of auriferous quartz reefs, which furnished no small portion of the pebbles of certain portions of the deposit, it is of course quite conceivable that a certain amount of detrital gold forms part of the conglomerate, but there are obviously no means of ascertaining what is the proportion of primary to secondary gold.

There seems, however, good reason for believing that by far the greater bulk of the gold, together with the pyrites, was introduced by solution percolating down to the most porous portions of the conglomerate, the condition being facilitated by the downward inclination of the bed rock, and possibly accentuated in part by the folding which the strata have undergone.

One of the most important advances in Western Australian geology is the recognition of a glacial conglomerate in the marine carboniferous rocks, near the tropic of Capricorn.

The carboniferous rocks of the State cover a wide extent of country, and bid fair to become of considerable economic importance.

The occurrence of Carboniferous rocks would seem to have first been made known through Sir George (then Lieut.) Grey in the year 1841, in his journals of the two expeditions of discovery in



North-Western and Western Australia during the year 1837-9. There are four districts in which fossiliferous Carboniferous rocks are known in the State, viz.:—Kimberley, the Gascoyne, the Irwin River, and the Collie Districts.

The Carboniferous rocks of Kimberley have recently been investigated by Dr. Jack, when in quest for artesian water. This observer's work was carried out in the months of December and January during one of the most severe droughts experienced in the district, and with a temperature often reaching 114 degrees Fahrenheit. Despite the fact that the route followed in investigating these beds, has perforce to be governed by considerations of grass and water, our knowledge of the Carboniferous rocks of Kimberley has been greatly extended. The formation is divisible into a lower or limestone series (in which limestone predominates) and an upper sandstone series (made up largely of sandstones and other sedimentary beds). The two series have been seen to succeed one another conformably in the Haughton Range, south latitude 19 S. and East Long. 127 E. Both series have yielded an assemblage of purely Carboniferous fossils:—*Lepidodendron*, sp.; *Stigmara*, sp.; *Stromatopora concentrica* (?) *Stromatopora placenta*, sp.; *Pachypora tumida*; *Zaphrentis*, sp.; *Syringopora* sp.; *Actinocrinus*, sp.; *Platycrinus*, sp.; *Poteriocrinus crassus*, Miller; *Pentremites*, sp.; *Serpula*; *Spirobis*, sp.; *Fenestella plebeia* (*antiqua*), McCoy; *Productus giganteus*; *Productus longispinus*; *Productus semireticulatus*; *Chonetes*, sp.; *Chonetes Hardrensis*; *Discina*; *Orthis resupinata*; *Strophalosia Clarkei*, Eth. fils; *Rhynchonella pugnus*; *Rhynchonella pleurodon*; *Rhynchonella cuboides*; *Orthotetes crenistria*, Phillips; *Streptorhynchus crenistria*; *Terebratula hastata* (?) *Terebratula sacculus* (?) *Pleurotomaria*, sp.; *Toxonema*, small sp.; *Natica*, sp.; *Ceripora*, sp.; *Chaetetes tumidus*; *Stenopora Tasmaniensis*; *Cyathophyllum*, sp.; *Cyathophyllum virgatum*; *Cyathophyllum depressum*; *Lithodendron affine*.

So far as observations on the Kimberley Carboniferous rocks have been carried, no boulder beds have yet been recognised, though in view of the occurrence of glacial conglomerates in India within 18 degrees of the Equator their presence in Kimberley would cause little surprise. The necessity for a further more or less detailed geological examination of a portion of the Kimberley district is at the present moment under consideration by the Government, and the solution of the many economic questions involved in the stratigraphical research which such an investigation entails is of no less importance to the community than the purely scientific results which of necessity follow.

The Gascoyne beds cover a very large area between the 22nd and the 26th parallels of South Latitude, and excellent sections of them may be seen in the valleys of the Wooramel, Gascoyne, Lyons,

Minilya, and Lyndon Rivers. Like their representatives in Kimberley, the strata are divisible into an upper or sandstone and a lower or limestone series. The sandstone series, which is seen resting conformably upon the limestone, is well exposed in the Carandibby, Kennedy, and the Moogooloo Ranges, making a bold outcrop of almost 200 miles in length. The beds forming these ranges were, until quite recently, regarded as of Mesozoic Age. The discovery, however, of *Spirifera*, *Athyris* (?) *Productus*, and *Strophalosia* in the Kennedy Range, near Trig. Station K 37, on the northern bank of the Gascoyne River, definitely sets at rest the conflicting views until quite recently held regarding their position in the geological time scale.

The country to the east of the Kennedy Range is underlain by fossiliferous beds of the limestone series, associated with which is the glacial boulder bed.

This bed, which forms a valuable stratigraphical horizon, has been traced across country for a distance of about sixty or seventy miles.

At the most southerly locality at which the boulder bed has been detected in Wooramel Valley, the boulders are of very large size, and is composed of rocks identical in character with those forming the older underlying rocks to the east, *e.g.*, granite and other crystalline and metamorphic rocks.

Some distance northward on the Wyndham River is a boulder bed in the limestone series. The bed, which at this spot attains no greater thickness than three feet, is crowded with boulders and pebbles of granite and crystalline rocks embodied in a calcareous fossiliferous matrix ; a photograph of a specimen of which contains fragments of *Spirifera Productus* and *Pozzoa*, in addition to *Aviculopecten tenuicollis*, will be found in the Annual Report of the Geological Survey for 1900. The pebbles and boulders have a large proportion of smooth and polished faces. The flats in the neighbourhood are covered with boulders and blocks of crystalline rocks evidently derived from the weathering *in situ* of the conglomerate which has a dip of about three degrees to the south-west. In the bed of the Wyndham River beds of flaggy sandy limestone are to be observed passing beneath the boulder beds indicating what is perfectly obvious from numerous sections that the glacial conglomerate does not lie quite at the base of the Carboniferous rocks.

Associated with the boulder beds of the Wyndham River are the following fossils :—*Hexagonella dendroidea*, Hudleston sp. ; *Pleurophyllum Australe*, Hinde ; fragments of *Crinoid* stems, and *Polyzoa* ; *Spirifera Musakheylensis*, Davidson ; *Spirifera Hardmani*, Foord ; *Spirifera lata*, McCoy ; *Reticularia lineata*, Martin sp. ; *Athyris Maccleayana*, Eth. fl. ; *Chonetes Pratti*, Davidson ; *Productus* (cf *Pteuni-straitus*, Foord).

Northwards from the Wyndham River the *débris* of the boulder bed makes its appearance in great force. The flaggy sandstones immediately underlying it are covered with large boulders of crystalline rocks. Near Barragooda Pool, on the Arthur River, a thick bed of limestone directly overlies the boulder bed. This limestone has yielded the following fossils :—*Evactinopora crucialis*, Hudleston ; *Rhombopora tenuis*, Hinde ; *Athyris Macleay* and Eth. fil Var. ; *Productus semireticulatus*, Martin ; *Aulos-teges*, sp. nov. ; *Dillasma*, sp. ind.

A few miles to the north of this, near Trig. Station K. 34, the Carboniferous beds are faulted against the older crystalline rocks which, in this locality, consist of quartz and mica schists, associated with either dykes or sills of porphyry.

In the southern branch of the Minilya River, near Trig. Station K. 49, the boulder bed is seen overlying beds of limestone and shale. The *débris* of the boulder bed consists of a heterogeneous collection of all sorts of crystalline and metamorphic rocks, and contains numerous ice-scratched pebbles ; photographs of several typical examples appear as Plate IV. of the Annual Report of the Geological Survey for 1900.

It may be mentioned in this place that in a deep bore put down by the Government at Pelican Hill, near Carnarvon, that these Carboniferous or Permo-carboniferous beds were met with beneath fossiliferous Mesozoic rocks at 1,406ft., and continued to 3,011ft., the present depth of the bore. The Carboniferous strata are represented by calcareous shales and limestone. The cores from the bore have yielded *Spirifera*, *Aviculopecten*, *Anthracopectera*, and *Favosites*. The bore, however, which did not pierce the whole thickness of the Carboniferous rocks gave no signs of the boulder bed. From the few salient features pointed out it appears quite clear that the glacial conglomerate is associated and interbedded with the fossiliferous limestones low down in the Carboniferous series as developed in this part of Australasia.

In the year 1897 I made a traverse up the Murchison valley in an exceptionally dry season, which seriously interfered with geological investigation, and at a point in the bed of the river, about 100 miles south of the boulder bed last mentioned, a conglomerate and breccia composed of angular fragments of a quasi-vitreous quartzite dipping at a low angle to the east was met with ; the base of the conglomerate was not visible anywhere, the most important and significant feature in this section is the fact that many of the pebbles were covered with scratches, not unlike slickensides.

A few yards lower down the river are a few beds of cross-bedded sandstones and fine conglomerates dipping east at an angle of about 20 degrees. One of the beds has been scored to such a degree as to produce surfaces as smooth and polished as plate glass.

The question arises, is this portion of a glaciated pavement, or is it due to faulting? If the latter, the faulting is nearly horizontal. Some distance further up the river, near the Forty Mile crossing and water reserve 1005, the sedimentary beds are inter stratified with coarse conglomerates or boulder beds; the boulders are principally quartz, though pebbles of sandstone and granite occur. I detected no scratched boulders in this section, though circumstances did not admit of any detailed search being made. The important point in connection with these conglomerates containing the scratched boulders is that they form part of what is at present believed to be the southern extension of the Carboniferous series of the Gascoyne, and form a connecting link between the latter and the Irwin River series, to which reference will be made later.

Beneath the Jurassic rocks of the Champion Bay District and in the valley of the Irwin River and its tributaries is a fairly extensive development of Carboniferous and Permo-carboniferous beds. In this district, as in Kimberley, it is possible to divide the strata into two distinct series, viz., the lower, or limestone, and the upper, or sandstone series.

Beneath the Irwin River coal seams are a calcareous shale and limestones, yielding a series of fossils, which have been carefully examined and described by Mr. Etheridge, of the Australian Museum, and will shortly appear as one of the Bulletins of the Geological Survey of Western Australia. The following fossils occur in these beds :—

*Nubecularia, Stephensi*, How ; *Pleurophyllum Australe*, Hinde ; *Fenestella fossula*, Lons. ; *Dielasma*, sp. ; *Seminula subtilita*, Hall ; *Spirifera*, sp. ; *Reticularia lineata*, Martin ; *Productus semireticulatis*, Martin ; *Productus tenuis-triatus*, var Foord Eth. fl. ; *Productus undatus*, DeFrance ; *Productus subquadratus*, Morris(?) ; *Chonetes Pratti*, Dav. ; *Aviculopecten Sprenti*, Johnston ; *Conocardium*, sp. Brom. ; *Stutchburia*, sp. Eth. fl. ; *Bellerophon costatus*, J. de C. Spy.

*Gastrioceras Jacksoni*, sp. nov. (the largest goniatite yet found in Australia, and of an entirely different type to the incomplete forms so far described).

The facies of these fossils is more akin to the Carboniferous than the higher Permo-carboniferous, and only four species are with certainty identical with those found in the Permo-Carboniferous rocks of Eastern Australia, viz. :—*Nubecularia*, *Productus subquadratus*, *Fenestella fossula*, and *Aviculopecten Sprenti*.

Associated with the marine series is a boulder bed, the debris of which strew the surface for a considerable distance, but there has as yet been no opportunity of investigating these beds in any detail. So far I have seen no striated pebbles among the boulders.

About 25 miles lower down the river, in the vicinity of Mingenew, and close to the railway line, are a series of ferruginous sandstones, on a higher horizon than the limestones, which remind one very forcibly of the sandstone series as developed in the Kennedy Range of the Gascoyne River. These beds have yielded the following fossils :—

*Dielasma nobilis*, sp. nov. ; *Dielasma hastata*, Dana ; *Spirifera*, sp. ind. ; *Spirifera avicula*, E. B. Spy ; *Cyrtina carbonaria*, var. *Australasica*, Eth. fl. ; *Cleiothyris Macleayana*, Eth. fl. ; *Productus Subquadratus*, Morris ; *Productus brachythoerus*, E. B. Spy ; *Chonetes*, sp. ind. *Deltopecten subquiquelineatus*, McCoy ; *Modiola* (?), sp. ind. ; *Myalina* (?) *Mingenewensis*, sp. nov. ; *Fenestella* or *Proloretepora*.

On the whole, it seems that the aspect of the fossils is that of the Permo Carboniferous of New South Wales.

It thus seems that there are in the Irwin River valleys beds of Carboniferous and Permo Carboniferous Age, and that the coal seams may possibly be the equivalents of the Greta Coal Measures of New South Wales.

The Collie River beds, which attain a thickness of a little over 2,000ft., are of considerable economic importance by reason of the fact that they contain coal seams to a total thickness of about 137ft., and are of some scientific interest in their relation to the important question of the distribution of the *Glossopteris flora*.

The Collie River coal field lies to the east of Bunbury and south of Perth, north-western edge of the tableland which succeeds the coastal plain. The field itself is traversed by the Collie River at an altitude of about 600ft. above the level of the sea. The area occupied by the Collie River coal measures is approximately 500 square miles. The beds consist of alternations of shales, sandstones, and grits, which rest directly upon granite schist and other crystalline rocks. The boundary of the field is, with one local exception, everywhere defined by faults ; on the south-western side of the field the boundary fault has been estimated to have a down throw to the north-east of at least 2,000ft.

There are several coal seams in the field of variable thickness, they consist in descending order of Cardiff No. 1, seam 9ft. to 12ft. thick.

Cardiff No. 2 or Boulder Seam, 7 feet thick.

Collie Burn No. 1 Seam, 9 feet thick.

Collie Burn No. 2 Seam, 6 feet to 7 feet 10 inches thick.

Coal (no name), 8 feet thick.

Proprietary No. 1 Seam, 4 to 8 feet thick.

Proprietary No. 2 Seam, 5 feet to 7 feet 6 inches thick.

Wallsend Seam, 9 to 17 feet thick.

The coal seams are hydrous, semi-bituminous, non-caking coals, which approach very closely to lignite in some parts; between the

various varieties the differences are only of degree for there are no distinctive characters which would find universal application. Owing to the conditions of deposition the coals naturally vary in character, and in places pass insensibly through forms containing a large proportion of earthy matter into carboniferous shales.

The question of the precise geological age of the Collie River beds is one about which there has been, and still is, considerable divergence of opinion.

In the year 1891, Mr. H. P. Woodward, the Government Geologist, assigned an early Mesozoic Age to the beds, basing his determinations principally upon the physical aspect of the field, and the chemical composition of the coals.

A little later some fossils were submitted to the late Mr. R. Etheridge, sen., who detected *Glossopteris* or *Neoggerthia*, and concluded that the beds were Permo Carboniferous.

In 1894, Mr. Woodward, basing his opinion upon the results of Mr. Etheridge's determination, referred the beds to the Upper Carboniferous.

In 1897, Mr. E. F. Pittman, Government Geologist, New South Wales, visited Western Australia, and in a report, referred the strata to the Mesozoic, on the strength of Mr. Etheridge's (jun.) doubtful recognition of *Sagenopteris*.

Upon a geological map accompanying a report by myself, published in 1898, the age of the beds was defined as uncertain.

In 1898, Sir Frederick McCoy reported the discovery of *Glossopteris Browniana* in some fossils sent to him by the Premier of the State, and stated that the beds were of "the exact geological age of the great coal fields of Newcastle, New South Wales." I may add, however, that these fossils were not collected by, nor were they ever seen by, any member of the geological staff.

Mr. R. Etheridge, jun., in his "Notes to accompany a miscellaneous collection of Western Australian fossils," submitted to him by myself in 1903, recognised undoubted *Glossopteris* in a good state of preservation, from the Moira Colliery, and constrained him to support the age assigned to the Collie River beds by his father, viz., Permo-Carboniferous. Mr. Etheridge carefully examined the *Sagenopteris* (?) obtained by Mr. Pittman, and in the same report abandons his previous determination, and now looks upon it as *Glossopteris*.

In 1904 Dr. Jack received a Commission from His Excellency the Governor to fully investigate all aspects of the Collie coal industry, including *inter alia* geological conditions. Accompanying the Commissioner's Report is an excellent geological map and

longitudinal section ; upon the former the age of the Collie River beds is set down as undetermined. Dr. Jack in his report says:—

The evidence bearing on the age of the Coalfield is at best inconclusive. High authorities have indeed expressed the opinion that it was of Palæozoic Age—Carboniferous, or Permo-Carboniferous—but all these opinions are founded exclusively upon the presence of the form *Glossopteris*, which is now known to range from Carboniferous to late Cretaceous. The shales are coarse-grained and incoherent, and badly adapted for the preservation of plant remains.

Dr. Jack draws attention to the fact that the various beds in the series are less coherent than is customary among the Carboniferous or Permo-Carboniferous formations of Europe, Africa, and Australia, and concludes:—

In a somewhat wide experience I have seen nothing which the Collie Coal Measures, coal seams included, so much resemble as the Oligocene Coal Measures of Croatia. While eagerly looking forward to the production of further evidence and open to conviction, I am at present inclined to believe that the Collie Coalfield will turn out to be possibly of Cretaceous Age, newer than the Coalfields of Ipswich and Burrum of Queensland.

The next and perhaps most important evidence bearing upon the controverted question is contained in some "Notes on fossils from the Collie Coalfield, Western Australia," in the "Collection of the National Museum, Melbourne," by Mr. F. Chapman, the Palæontologist to the Natural History Museum, Melbourne, just about to be printed as one of the Bulletins of the Geological Survey of Western Australia.

This writer recognised the plants:—*Glossopteris browniana*; *Glossopteris browniana* var *indica*; *Glossopteris browniana* var *communis*; *Glossopteris browniana* var *angustifolia*; *Glossopteris browniana* *gagamopteroides*.

And in the associated sandstones the following Foraminifera:—*Endothyra*; *Valvulina plicata* (U. Carb. List, England); *Bulimina* (Permo-Carboniferous, N.S.W.); *Truncatulina haidingeri* (Permo-Carb., N.S.W.); *Pulvinulina exigua*.

The *Valvulina* of Collie, though very much dwarfed, is essentially a Carboniferous form whilst the other species Mr. Chapman detected and described point in a general way to the Palæozoic Age of the series.

Mr. Howchin pointed out in 1893, in his "Census of the Fossil Foraminifera of Australia," that the Australian Palæozoic foraminifera show a closer affinity with the Permian fauna of the Northern hemisphere than the Palæozoic.

In view of all the evidence at present to be deduced from the plant remains and the marine organisms in the beds associated with the Collie coal seams, despite the nature of the coal and the physical characteristics of the basin, I am constrained to admit that a Permo-Carboniferous Age of the series presents the strongest claims to

acceptance. I make no excuse for the fact that my present views on this much debated question are not those I previously held, but our most cherished opinions, like everything else, must yield to that stern logician—fact.

Jurassic rocks have been found up to the present in only one district—that of Champion Bay, near Geraldton; but the beds have not been investigated in any detail by the Survey, hence our information about them is at the best somewhat meagre.

Mr. Crick, of the British Museum, in a paper on “A Collection of Jurassic Cephalopoda, from Western Australia,” records *Ammonites* (*Perisphinctes*) *Championensis* from Cape Riche, to the East of Albany, and naturally claims a Jurassic Age for the beds.

In 1898 I visited Cape Riche. The beds consist of sandy limestones, which extend between Cape Riche and Warriup, and are fossiliferous. The Cape Riche beds have yielded:—Impressions of a Cycadaceous leaf (?) *Hemiaster*, sp.; *Pectunculus*, near *P. flabellatus*; Ten. Woods, internal casts of *Cytherea*, *Arca*, *Lima*, *Mactra*, *Amusium* and *Voluta*, in addition to *Venus*, near *V. Voseo-tineta*, Baird.

The Warriup beds have yielded:—*Cardium*, sp.; *Cardium hemicardium*, Linn; *Trochus personatus* (?) Phil. and *Arca reticulata*, G.M. These strata would therefore seem to be either recent or very young Tertiary. Even assuming that the Cape Riche series turn out on further investigation to be Secondary, I do not think the Jurassic can put in any claim for recognition. I am, therefore, inclined to think that Mr. Crick's Ammonite recorded from Cape Riche has been wrongly localised, and really came from Champion Bay.

The Champion Bay Jurassic beds cover a fairly large area of country to the south in the neighbourhood of the coast line; they are seen to rest with a violent unconformity on the Carboniferous rocks of the Irwin River valley. They also probably extend northwards, for in the deep bore near Carnarvon strata high up in the Mesozoic series have been recognised, between 1,200 and 1,500 feet.

The Champion Bay beds consist of oolitic limestones, clays, sandstones, grits, and conglomerates. Fossils are abundant, and they include a considerable number of Cephalopoda:—*Belemnites*, sp.; *Nautilus perornatus*, sp. nov.; *Ammonites* (*Dorsetensia*) *Clarkei*, sp. nov.; *Ammonites* (*Stephanoceras*) *Australe*, sp. nov.; *Ammonites* (*Sphaeroceras*) *Woodwardi*, sp. nov.; *Ammonites* (*Sphaeroceras*) *semiornatus*, sp. nov.; *Ammonites* (*Perisphinctes*) *Championensis*, sp. nov.; *Ammonites* (*Perisphinctes*) *robinginosus*, sp. nov. There have also been obtained:—*Trigonia Moorei*, Lycett, *Myacitus Sandfordii*, Moore; *Lima*, sp.; *Lima* allied to *L. pectiniformis*, Gold; *Cucullæa semi-striata*, Moore; *Pleuromya*, *Astarte Cliftoni*, Moore; *Cresslya*, sp.; *Gryphaea*, sp.; *Mytilus* allied to *M. Cygærensis*, D'Orb; *Pecten frontalis*, Dumortier.



No estimate can as yet be made of the thickness of these Jurassic beds; they have, however, been pierced by four bore holes in the Champion Bay district, the deepest being at Dongara. This bore was sunk for the purpose of the delimitation of the seaward extension of the Irwin River coal measures, which there are good grounds for believing to lie beneath the Mesozoic beds. The bore attained a depth of 2,111 feet when operations were stopped owing to the capabilities of the boring plant being exhausted without the base of the Jurassic rocks having been reached. There are thus over 2,000 feet of these beds in this locality.

The recognition by Mr. W. D. Campbell of the remnants of an extensive dolomitic limestone formation at an altitude of about 900 feet above the level of the sea at Norseman, and distant about 100 miles due North from the coast at Esperance Bay (Long. 122 degrees East) containing fossils of either late Tertiary or Recent Age is, perhaps, next to the Carboniferous Glacial beds, one of the most important of the recent advances in our knowledge of the younger geological formations.

Two small outliers of this formation occur on the western bank of Lake Cowan and four near Lake Dundas. The beds, which in the vicinity of Norseman occupy but a very small area, consist principally of a dolomitic limestone, with several siliceous bands. These beds contain species of *Turitella*, allied to *T. terebra*; *Pecten*, *Cardium* (or *Cardita*) *Magellania*, and fragments of *Polysoa*. These discoveries are of considerable importance, and must be thoroughly examined some day, as they involve a whole series of important conclusions which depend upon the age of the fossils the beds contain.

At Balladonia, many miles to the east and in what is known as the Eucla limestone plateau, the flesh coloured limestones have yielded:—A *Pecten*, allied to *Chlamys asperimus*, Lamck; near Madoura Station a shell agglomerate yielded *Venus peronii* var *conularis*, Lamck; and *Tapes*, probably *T. Avaneosus*, Phillipsi, a living species. These fossils seem to indicate a deposit of comparatively recent age.

Entering the State at its eastern frontier in the Nullabor Plains, and extending without any interruption as far as Israelite Bay, is very large development of strata of Recent and Tertiary Age. These strata consist of flesh-coloured limestones associated with sandy porous beds, into which the rainfall is rapidly absorbed and discharged seawards in the form of fresh water springs, and are the western extension of the beds pierced in the five bores in South Australia.

These beds form what is known as the Premier Downs. An immense limestone plateau extending from Goddard's Creek (E. Long. 124 degrees) to the South Australian frontier, terminating abruptly along its southern border by a conspicuous escarpment

400 feet high in some places. The limestone plateau extends for miles into the interior, and the average altitude (so far as can be ascertained) of the inland margin is about 1,000 feet above sea level.

The bore nearest the Western Australian frontier is at Albalakaroo, on or near the telegraph line at about 45 miles east of Eucla. This bore attained a total depth of 1,084 feet, and bottomed on granite at 1,073 feet, after passing through (in descending order) 565 feet of (Eucla) limestone, 426 feet of clay (shale), and 82 feet of a "hard rock," which those in charge of the operations could not determine.

Two bores have been sunk by the Western Australian Government near Madura. No. 1 bore was put down at a point 110 feet above sea level, and distant 30 chains south of the Eucla limestone escarpment, which is 350 feet high. The bore was carried down to a total depth of 2,041 feet, and passed (in descending order) through about 766 feet of limestone, underlaid by alterations of clay shale, sometimes Glauconitic dolomitic limestone. The bore ended in a soft mudstone. The second or No. 2 bore was situated 30 miles to the north of No. 1, on the limestone plateau, and about 300 feet above the level of No. 1. It was carried down to a depth of 412 feet, and passed through nothing else but limestone—the Eucla limestone. The sequence of strata in the Western Australian bores coincides in its essential particulars with that indicated by the South Australian bores, and there can be very little doubt as to identity of the two series of beds whatever may be their age.

*Laterite.*—No mention of the recent advances in Western Australian geology would be complete without some reference to that extensive development of residual deposits which have been found over the whole length and breadth of the State.

The term laterite has been officially adopted, though in a somewhat more extended sense than its original application, for all the deposits resulting from the decomposition and reconsolidation of rocks *in situ*.

The laterites of Western Australia consist largely of hydrated oxide of iron and alumina, producing on the one hand deposits of excellent iron ore and on the other bauxite. In some parts of the State the deposition of secondary silica in the lateritic deposits produces what are practically quartzites; these, by an increase in the ferruginous colouring matter, pass into a jasperoid form of laterite. There are thus three forms of these laterites—an aluminous, a ferruginous, and a siliceous—the composition being liable to vary considerably over a small area, it being largely governed by the nature of the underlying rocks.

The structure is sometimes massive and almost homogeneous, but is more frequently pisolitic and nodular, in which case the concretions are richer than the interstitial matter.

The lateritic deposits naturally vary in their lithological characters. They are often very porous and weather into caverns and cavities of all sizes. The surface of the rock is often covered with a glaze of hydrated oxide of iron. When freshly broken the rock presents a mottled appearance owing to the different shades of brown, yellow, and red. The rock passes gradually into the underlying rocks without any sharp line of demarcation. That ferruginous and siliceous laterites are more commonly met with is due to the fact that deposits of this type are better able to resist disintegrating influences than the softer varieties; they thus not only remain themselves, but act as a protecting cover for the rocks beneath.

Mr. J. Beete Jukes, writing in 1850, in his almost classic "Sketch of the Physical Structure of Australia," mentions the occurrence of these lateritic deposits as seen by him in the country between Perth and York. He says :—

For a few feet below the surface the rock was a singular concretionary ferruginous compound which looked like a clay or sandstone that, being highly ferruginous, had formed itself into a mass of small balls and irregular concretions of a black oxide of iron or hematite. Below this ironstone (which is its name in the Colony) wherever the rock was exposed it appeared for many miles to be granite or some granitic compound.

In another place he mentions as occurring in one of the lateral valleys of the Swan River—

A thin capping of ironstone forming a line of small crags.

In 1861 the late Mr. F. T. Gregory gives in his paper "On the Geology of a part of Western Australia," an account of this lateritic deposit capping the Darling Range, and claims for it a Devonian Age. This observer mentions the important fact that the deposit blends gradually with the upper surface of the granite, and states that it would seem to owe its origin to the decomposition of the granite *in situ*.

The Rev. W. B. Clarke, in his "Sedimentary Formations of New South Wales," remarks :—

Mr. F. T. Gregory indicated on his map and in his report the existence of Devonian Rocks near York, and in other parts of that Colony. Having examined the rocks so indicated, I can only state my belief that they have no pretension to any such antiquity and are probably mere collections of loose granitic matter, and other drift cemented by ferruginous paste, which has since become transmuted into concretionary nodules and hematite. There are also pebbles of trap, much decomposed in the so-called Devonian. They may be perhaps more properly considered as representing the Laterite of India.

It is on these historical grounds that Laterite has been adopted in Western Australia as the name for these residual deposits rather than the term Saprolite, which American writers have suggested.

The various reports of the Geological Survey contain numerous descriptions of these lateritic deposits, and are often accompanied by analyses.

These analyses show variations in alumina from 7.52 to 44.66 per cent. ; ferric oxide, 10.02 to 88.23 per cent. ; silica, 1.53 to 23.26 per cent. ; combined water, 8.10 to 26.44 per cent. ; and oxide of titanium, .59 to 3.10 per cent.

A recent analysis of a ferruginous laterite from Comet Vale (North Coolgardie) is of interest

On account of the high percentage of chromium, mostly in the form of a hydrate readily soluble in hydrochloric acid, the balance being present in the form of chromite.

The analysis gave 79.01 per cent. of ferric oxide, 5.30 per cent. of chromic oxide, 3.14 per cent. of silica, and of water 12.35 per cent. Some of the laterites have proved to be more than appreciably auriferous.

In the southern portion of the State where the rainfall is greatest, the lateritic deposits support an abundant vegetation. The well-known karri and jarrah growing in all their splendour thereon. In fact the mapping of the lateritic deposits of this portion of the State would define the areas over which both karri and jarrah occur.

Elsewhere in the State the laterites support but a scanty vegetation.

So far as our observations have been extended the laterites, for the reason previously given, occur as disconnected outliers, which once formed part of a continuous deposit. It is difficult to escape the conviction that since they were deposited, a considerable time may have elapsed, hence the laterites may be of some geological antiquity of which possibly the thickness and the state of consolidation may be some measure.

We have, however, as yet, little authentic evidence on this point, though it may be mentioned that a bore put down at Coolgardie, on Reserve No. 23, certain plant remains were found in a deposit containing what is evidently the detritus of the lateritic beds. These plant remains have, on examination, been held to belong to the *Eucalypti*. McCoy has described definite eucalyptus foliage from the older gold drifts in Victoria, whilst Ettinghausen describes several species from the Upper Tertiaries of New South Wales and deep lead in the New England Tinfield.

On this evidence, therefore, the laterites seem to be of earlier age than the Tertiary, though there is but little doubt that lateritic deposits are forming at the present time.

### III.—*Volcanic Rocks.*

Volcanic rocks have played an important part in the geological history of Western Australia, and the evidences of this igneous ac-

tivity are to be found in the form of lava flows, ash beds, breccias, dykes, stills, etc., which make a prominent feature in certain portions of the State.

Many writers and observers, it must be noted with regret, treat volcanic rocks in such a fashion as to suggest that they constitute a more or less meaningless interpolation in geological history, and I have no desire to be included in the same category.

There are, so far as is at present known, three distinct periods in which Western Australia has been the scene of igneous activity of more or less intensity. These periods are :—

- (a.) In Pre-Cambrian time, prior to the deposition of the beds containing the Olenellus fauna. These old igneous rocks are of importance in the part they appear to have played in connection with the formation of the ore deposits of the State. These have been more or less fully described in the opening portions of this address.
- (b.) A period commencing early in the Nullagine (Devonian) time, but ceasing before the Carboniferous. The interstratification of lavas and ashes with the sandstones and conglomerates point to subaqueous eruptions, though from the amygdaloidal nature of many of the lavas, the bulk of these volcanic rocks must, I think, be sub-aerial. Several of the focii from which the lavas, etc., emanated, have been noticed. The magnificent series of basic dykes of the North-West and elsewhere, to which reference has already been made, suggest to one who has examined the Devonian Volcanic Series, that fissure eruptions, of which these dykes may form part, have been in some way responsible for the wide extent of the lava flows, which cover some hundreds of square miles.
- (c.) After the deposition of the Jurassic Beds, and believed to be of Tertiary Age, they consist of basic lavas and ashes, which occur in great force in the Kimberley District.

In the Ord and Bow River valleys these lavas appear to have levelled up the depressions formed therein (except certain knife edge ridges of the older rocks, which still protrude above the level) and in places rest upon the Devonian Volcanic plateau. On the Behn River, just above what is known as the "Gorge," Dr. Jack noted a dome or "pug" of basalt, which apparently formed the focus from which some of these lavas issued.

At Bunbury, and one or two points on the coast round the south-west corner of the State, bedded columnar basalts occur. Over large areas, and far into the interior, numerous volcanic eject-

menta, in the form of obsidian bombs occur, and were probably derived from volcanoes of which no trace has yet been found, it is quite possible they may owe their origin to that volcanic region which skirts the northern coast of Australia.

The geological age of these basaltic lavas in the present state of our knowledge is a matter for inference only, but if we assume that they all belong to one period, they must be set down as Tertiary.

Some of the basic intrusive dykes, which are also widely distributed in the North-West, and form such pronounced features in the scenery, belong to a later period, that of the volcanic eruptions of Nullagine (Devonian) times; for many cases have been noticed in which they traverse the Nullagine Beds for many miles. Since the Nullagine volcanic fires became extinct Western Australia appears to have known no outbreak of igneous activity until pretty well Tertiary times.

The history of volcanic action in Western Australia is thus the history of Pre-Cambrian, Devonian, and the Tertiary periods.

It is hardly possible within the scope of a single address to consider the whole question of the Geology of Western Australia. My object has been to point out what light has been thrown thereon through recent investigations, by merely touching the fringe of the subject, and my task has now been completed.

In the fulfilment of the task I have endeavoured to inflict to the full that punishment which, by the irony of fate, seems to be the recognised method by which a President conveys his appreciation of being made the recipient of one of the highest honours which his scientific brethren have within their power to bestow.

Whether or not I anticipate your endorsement of or disagreement with the verdict that the "Punishment fits the Crime," I *know* that I am voicing your feelings when I say that during our efforts to wrest from Mother Earth those secrets which are graven in mystic characters on her face, we geologists by merely wandering over the surface, exchanging the genial sunlight for the feeble flicker of the miner's candle, peering down the tube of the petrological microscope, calling to our aid the delicate chemical balance, or poring over the "Medals of Creation" in the seclusion of the Museum Cabinet, re-echo the sentiments of one of Germany's greatest poets and thinkers.

"Ach, wunderschön ist Gottes Erde!"

"Und schön auf ihr ein Mensch zu sein."

A. GIBB MAITLAND,

Government Geologist.

## 8.—Prevention of External Corrosion of Goldfields Water Supply Pipes.

### (a.) PRELIMINARY REPORT.

*Nature and Causes of Corrosion.*—Before any suggestions could be made for the prevention of external corrosion of the Goldfields Water Supply pipes, it has been necessary to ascertain beyond doubt the causes of the corrosion, and as the result of experiments made, the following conclusions have been drawn :—The corrosion of steel in this case, as in most others, consists in the formation of a porous impure hydrated oxide of iron, rust, at the expense of the solid metal, owing to the interaction of the latter with water, and the oxygen dissolved by it out of the air, or otherwise derived. More particularly rust has been shown recently by Dr. Moody in a paper to the Chemical Society to consist mostly of the ferric hydrate,  $\text{Fe}_2\text{O}_3 \cdot (\text{HO})_3$ , with more or less small proportions of ferrous hydrate  $\text{Fe}(\text{HO})_2$ , and ferrous carbonate  $\text{FeCO}_3$ , a result borne out by the experiments carried out by Dr. Earp and myself upon the rusting of the metal of the Goldfields Water Supply pipes, of which more anon.

It may be taken as an axiom that no chemical action can take place at ordinary temperatures between two permanent and dry solids, owing to the inertness of the molecules in the solid state, and to the impossibility of establishing sufficiently intimate connection between them. The presence of a third substance in the liquid or gaseous state, which is capable of dissolving even traces of either substances, sets up a condition of affairs very much more favourable to chemical action, since the dissolved molecules are in a far more active state than before, and intimate connection is assured per medium of the liquid or gas, whilst, most important of all, electrochemical action may also come into play.

One other fundamental fact must be noted. The most modern researches in chemistry have established the fact that in very many cases of chemical action the most important (chemical) factor is not the overwhelming proportion of the two main substances acting, but those apparently insignificant traces of other substances, which either profoundly alter the nature of the main materials, or else, in ways still obscure in many cases, more or less greatly enter themselves into the chemical actions going on and retard or accelerate them.

All these considerations bear directly upon the subject of this research, viz., the cause of the more or less rapid corrosion of the external surface of mild steel pipes laid underground. For, in the first place, we may assume without hesitation, that perfectly dry soil in contact with perfectly dry pipes, whether coated or not with any form of paint, would not cause the pipes to corrode. Steel will undoubtedly corrode to a very slight extent if suspended in

air out of reach of rain or other visible moisture, since even the driest air contains water in solution, and thus three essentials to the formation of rust, viz., water, oxygen, and carbonic acid, are in contact with the steel. Such corrosion is undoubtedly extremely slow (except when, owing to the proximity of burning coal, sulphurous acid vapours exist in the air), and is reduced to an infinitesimal amount by coating the metal with any relatively inactive and impervious material, such as an asphaltic or graphite paint. The asphaltic paint (tar, asphalt, and maltha) used in coating the Water Supply pipes seems to have been, where not removed by rough handling, etc., very impervious and closely adherent, and therefore an excellent preservative. The corrosion from air is quite negligible therefore.

A much more active cause must be looked for, and failing air, this was sought for in the soils. A number of these have been examined, and more still being analysed with the greatest care, owing to the interesting results obtained up to the present. The soils consist for the most part of quartz sand, clay, and iron oxide in varying proportions. There is very good reason for believing that none of these main constituents exerts any chemical influence on the pipes. Vegetable matter is practically absent. Two causes of corrosion suggested themselves, viz. :—

1. The presence of pyrites in the soil undergoing oxidation in the presence of water and air with the production of sulphuric acid. Except possibly in one case, this was proved not to be the case since pyrites were absent, and on treatment of the soils with water the solution far from being acid was found to be alkaline, owing to the presence of carbonate of lime.
2. The presence of moisture in the soil, associated with an electrolyte (or substance capable of carrying an electric current) in the form of a salt of some strong mineral acid. In the light of the experiments made, there appears to be no doubt that this is the main, if not the sole cause of the corrosive effects observed.

Recent experiments in England have shown that :—

- (a.) Chemically pure water is without effect upon iron or steel, such water being practically a non-conductor of electricity.
- (b.) The addition of pure oxygen to chemically pure water does not make it more active towards iron.
- (c.) The further addition of an electrolyte of the kind mentioned, such as common salt, gypsum, etc., sets up galvanic action, resulting in the formation of free acid and consequent active corrosion.

The electrolytic decomposition of an oxygen salt, such as a sulphate or carbonate, liberates at one pole (the anode) free oxygen



together with the free acid corresponding to the salt, viz., either sulphuric or carbonic. The similar decomposition of a chloride yields chlorine in solution, an energetic solvent for iron. It is evident, therefore, that if any plate, or portion of a plate of iron or steel becomes the anode in the presence of a solution of such an electrolyte, energetic corrosion of that plate is to be expected.

The very modern science of metallography has shown that steel in common with most other commercial metals, is not a perfectly homogenous substance, but a mixture of two or more alloys. In the case of mild steel of the nature used in these pipes, the internal structure is found to be a main mass of "Ferrite," which is almost chemically pure iron, and embedded in this mass numerous small grains of "Cementite," a carbide of iron ( $\text{Fe}_3\text{C}$ ), more or less regularly distributed. In these two constituents of the steel plates we have the necessary poles and connections to form, when in contact with a solution of an electrolyte, a series of small batteries, each causing corrosion.

Ferrite is a highly electro-positive substance, and therefore dissolves with comparative rapidity. Cementite is more electro-negative, and being also the cathode is but little affected by the action. That this electrolytic effect is not so small as one might at first expect is shown by the use to which it is put in determining the constituents of iron and steel by the etching of polished surfaces.

To obtain a rough quantitative idea of this action a series of experiments has now been made, using relatively pure water and solutions in water of the various electrolytes normally occurring in soils. A number of small bars, 3in.  $\times$   $\frac{3}{4}$   $\times$   $\frac{1}{4}$  were cut from the metal of which the pipes in question are made, and roughly polished, these were then put in an upright position into well-stoppered bottles, and covered for half their depth with the following liquids:—

1. Distilled water, freshly boiled to remove all oxygen and carbonic acid.
2. Distilled water that had been standing some days and had probably absorbed considerable oxygen and carbonic acid from the air.
3. Distilled water saturated with carbonic acid.
4. Freshly boiled distilled water saturated with calcium carbonate (0.01 per cen. solution).
5. Do. with magnesium carbonate.
6. One per cent. solution of sodium bicarbonate.
7. Do. of calcium chloride.
8. Do. of magnesium chloride.
9. Do. of sodium chloride.
10. Saturated solution of calcium sulphate.
11. One per cent. solution of magnesium sulphate.
12. Do. of sodium sulphate.
13. Solution containing  $\frac{1}{2}$  per cent. each of magnesium chloride and sodium nitrate.

14. Do. sodium chloride and sodium nitrate.
15. One per cent. solution of sodium nitrate.
16. Water extracts of soil No. 1926.
17. Do. of No. 1962.
18. Do. of No. 1963.
19. Do. of No. 1924.
20. Do. of No. 1957.
21. Do. of No. 1956.

The results of these experiments were extremely interesting, in every case but one a noticeable amount of corrosion had taken place within the space of an hour, as shown by the formation of rust on the surface of the plates, and the appearance of a precipitate or deposit of iron oxide in the solutions surrounding them. The effects were watched for two days, when the steel bars were removed, and the iron removed from them was estimated.

These experiments show that :—

- (1.) Rusting takes place in comparatively pure water containing a little oxygen and carbonic acid.
- (2.) That the amount of rust formed is nearly double in the presence of a little common salt, sodium carbonate, or a mixture of magnesium chloride and sodium nitrate; whilst it is considerably increased in the presence of a little calcium carbonate, chloride or sulphate, magnesium sulphate, sodium sulphate, or nitrate. All these salts occur in the soils examined.
- (3.) Water extracts of three soils where the pipes were said to be very bad yielded nearly double the amount of rust yielded by pure water.

This being so, the soils were examined with a view to determine the nature and quantity of the soluble salts contained in them. The following table gives the results in percentages of the soil :—

Laboratory No. ... ..	1835	1812	1814	1815	1816
Locality, miles and chains	17-35	128-72	129-20	129-68	183-00
Condition of pipes ... ..	Bad	Bad	Fair	Very Good	Good
Calcium carbonate... ..	·014	·002	·088	·062	·025
Magnesium „ ... ..	...	·019	...	·020	·036
Sodium „ ... ..	...	·015	...	·014	·014
Calcium sulphate ... ..	·083	...	·002	...	...
Magnesium „ ... ..	...	...	·040	...	...
Sodium „ ... ..	...	·085	...	·013	·178
Sodium nitrate ... ..	...	Trace	·019	Trace	...
Calcium chloride ... ..	·037	...	...	...	...
Magnesium „ ... ..	·037	...	·003	...	...
Sodium „ ... ..	·076	·082	·200	·084	·385
Iron oxide and alumina ... ..	·010	·082	·015	·020	·014
Silica ... ..	...	...	...	...	·014
Total ... ..	·207	·176	·317	·108	·538
Nature of soil ... ..	Weathered diorite and grey clay	Coarse, grey, very sandy clay	Light brown, very sandy clay	Light brown, very sandy clay	Buff, very sandy clay

Laboratory No. ... ..	1861.	1862.	1863.	1864.	1868.
Locality, miles and chains	183-17	192-00	201-16	216-66	218-40
Condition of pipes ... ..	Good	Good	Fair	Bad	Fair
Calcium carbonate ... ..	·011	·014	·028	·025	·025
Magnesium " " " " " "	...	·002	·004	·023	...
Sodium " " " " " "	...	...	...	·006	...
Calcium sulphate ... ..	·024	...	...	...	·023
Magnesium " " " " " "	·025	·032	·024	...	·056
Sodium " " " " " "	·070	·061	·050	·065	·084
Sodium nitrate ... ..	...	...	...	...	...
Calcium chloride ... ..	...	...	...	...	...
Magnesium " " " " " "	...	...	...	...	...
Sodium " " " " " "	·266	·009	·018	·249	·162
Iron oxide and alumina ...	·028	·034	·012	·012	·011
Silica ... ..	·013	·006	·016	·038	·010
Total ... ..	·437	·158	·152	·438	·320
Nature of soil ... ..	Brown sandy clay	Yellow clayey sand	Light grey, sandy clay	Brown sandy clay	Light brown clay

Laboratory No. ... ..	1869.	1870.	1871.	1890.	1921.
Locality, miles and chains	241-01	267-70	306-70	313-40	315-40
Condition of pipes ... ..	Fair	Good	Fair	Fair	Bad
Calcium sulphate ... ..	·025	·009	·025	·086	·025
Magnesium " " " " " "	·016	·009	·002	·009	·011
Sodium " " " " " "	...	...	...	...	·019
Calcium sulphate ... ..	...	...	...	...	...
Magnesium " " " " " "	·087	·001	·029	·013	...
Sodium " " " " " "	·020	·024	·148	...	·0-0
Sodium nitrate ... ..	·012	...	...	...	...
Calcium chloride ... ..	...	...	...	...	...
Magnesium chloride ... ..	...	...	...	·005	...
Sodium " " " " " "	·284	·084	·018	·080	·088
Iron oxide and alumina ...	·024	·007	·012	·004	·006
Silica ... ..	·006	·006	·022	·011	·036
Total ... ..	·424	·140	·256	·100	·132
Nature of soil ... ..	Light brown clay	Buff, very sandy clay	Dark brown clay	Brown sandy clay	Red sandy clay

Laboratory No. ... ..	1922.	1923.	1898.	1810.	1921
Locality, miles and chains	320-40	323-00	324-60	332-10	335-20
Condition of pipe ... ..	Bad	Bad	Bad	Good	Very bad
Calcium carbonate ... ..	·018	·021	·002	·025	·018
Magnesium carbonate ...	·014	·006	·024	·009	·005
Sodium " " " " " "	·046	...	...	...	...
Calcium sulphate ... ..	...	...	...	...	...
Magnesium sulphate ... ..	...	·019	·006	·084	·013
Sodium " " " " " "	·015	·008	·005	·045	·027
Sodium nitrate ... ..	...	Trace	·006	·013	...
Calcium chloride ... ..	...	...	...	...	...
Magnesium chloride ... ..	...	...	...	...	...
Sodium " " " " " "	·036	·302	·062	·208	·018
Iron oxide and alumina ...	·014	·006	·018	·032	·001
Silica ... ..	·016	·006	...	...	·011
Total ... ..	·159	·370	·125	·361	·091
Nature of soil ... ..	Red clay	Brown clay	Brownish grey sandy clay	Brown, very sandy clay	Brown sandy clay

Laboratory No. ... ..	1925.	1926.	1956.	1957.	1958.
Locality, miles and chains	336-18	336-38	340-50	353-77	354-21
Condition of pipe ... ..	Very bad	Very bad	Very bad	Fair	Fair
Calcium carbonate ... ..	·003	·023	·009	·019	·039
Magnesium carbonate ... ..	...	...	·005	·016	...
Sodium ... ..	...	...	·011	·019	...
Calcium sulphate ... ..	·018	·098	...	...	·073
Magnesium sulphate ... ..	·031	·057	...	...	·050
Sodium ... ..	...	·011	·084	·105	·108
Sodium nitrate ... ..	...	...	...	...	...
Calcium chloride ... ..	...	...	...	...	...
Magnesium chloride ... ..	·003	...	...	...	...
Sodium ... ..	·032	·036	·036	·039	·053
Iron oxide and alumina ... ..	·004	·004	·016	·015	·006
Silica ... ..	·005	·007	·008	·011	·005
Total ... ..	·128	·225	·119	·274	·331
Nature of soil ... ..	Red sandy clay	Red sandy clay	Brown sandy clay	Red sandy clay	Red sandy clay

Laboratory No. ... ..	1959.	1960.	1961.	1962.	1963.
Locality, miles and chains	357-43	376-40	379-42	382-63	385-06
Condition of pipe ... ..	Bad	Bad	Bad	Good	Fair
Calcium carbonate ... ..	·022	·016	·017	·014	·023
Magnesium carbonate ... ..	...	·011	...	·012	·014
Sodium ... ..	...	·026	...	·029	·006
Calcium sulphate ... ..	·274	...	·189	...	...
Magnesium sulphate ... ..	·120	...	·171	...	...
Sodium ... ..	·278	·054	·482	·027	·037
Sodium nitrate ... ..	...	...	·004	...	...
Calcium chloride ... ..	...	...	...	...	...
Magnesium chloride ... ..	...	...	...	...	...
Sodium ... ..	·102	·035	·506	·027	·146
Iron oxide and alumina ... ..	·002	·001	·003	·002	·002
Silica ... ..	·001	·005	·005	·013	·010
Total ... ..	·799	·150	1·377	·124	·246
Nature of soil ... ..	Red clay	Red clay	Red clay	Brown clay	Brown clay

This table shows that the whole of the soils examined contained soluble salts, varying in amount from one-tenth to one and a-third per cent. Corrosion more or less intense is therefore to be expected at all the points from which the samples were taken. This corrosion will be entirely prevented by the asphaltic covering where intact, but wherever it is chipped or scratched the pipe will be open to attack. This attack will be dependent upon—

(1.) The frequency with which the soil is wetted by rain or leakage.

(2.) The extent to which the soil retains moisture after rainfall owing to its topographical position or its physical struc-

ture. Clay pans and flats will be moist long after the ridges have dried and stiff clay will retain moisture for weeks after loose sand has lost all such through evaporation.

(3.) The quantity and nature of soluble salts in the soil. Within the limits shown by the analyses the effect will, as a rule, be greater where the total amount of salts is greater, but will be dependent still more upon whether or not those salts are derived from acids which have a strong affinity to iron. Chlorides, sulphates, and nitrates may be expected to have the worst effect.

Finally localisation of attack will result from localisation of exposed surfaces or of salts or moisture in the soil, and from lack of homogeneity of the steel.

*Prevention of Corrosion.*—Having thus arrived at a definite conclusion with regard to the causes of corrosion, it is a comparatively simple matter to suggest means of prevention, though the relative expense and adaptability of these means are matters for the consideration of the engineer in charge.

In short, what must be avoided is to allow moist soil to remain in contact with the bare metal of the pipes for any appreciable part of the year, especially where the ground is salty. This object is to be attained by—

- (1.) Continually renewing the coating of the pipes, so as to preserve it practically intact.
- (2.) Reducing leakage to a minimum.
- (3.) Diverting all surface water from the pipe line.
- (4.) Assisting the soil to dry up rapidly after rainfall.

This latter point is the only one which needs elucidation. The air of the interior is so dry at all seasons of the year and at times so hot, whilst the rainfall is so slight, that loose sandy soil will dry naturally too quickly to allow of extensive corrosion taking place. Stiff clay soils are however so retentive of moisture that where the soil is of this nature extra supervision of the pipes should be maintained with a view to keeping the coating intact, whilst the covering of soil should be reduced to a minimum, or even done away with, and any steps, locally applicable, taken to facilitate the draining and drying of the soil in the immediate vicinity of the pipes.

Renewals of the pipes will have to be undertaken as time goes on, and before such are made it would be well to have a thorough investigation made into the question of the suitability of mild steel for such work in the salty soils of the interior. Reasons, both practical and theoretical, point to its being far from an ideal material for such work.

In conclusion, I must acknowledge my indebtedness to Dr. F. S. Earp in the preparation of this report, that gentleman having made most of the necessary estimations and analyses.

EDWARD S. SIMPSON, B.E., F.C.S.,  
Mineralogist and Assayer.

(b.) SECOND AND FINAL REPORT.

Since the presentation of my preliminary Report upon the corrosion of the G.W.S. pipes, the work of Dr. Earp and myself has been chiefly upon the completion of the analyses of soils from various parts of the pipe-line, upon determining the relative effect of these soils upon different brands of metal and upon experimenting with various substances likely to neutralise or retard the evil effect of the soils.

*Analyses of Soils.*—The accompanying Table 1 gives the analyses of 29 more soils from the pipe-track.

The variable action of these soils is dependent upon several independent factors, viz.:—

- (a.) The state of the pipe coating.
- (b.) The percentage of salts in the soil.
- (c.) The capacity of the soil for retaining moisture.
- (d.) The drainage of the soil.

The irregular pitting of the pipes has been imitated in the laboratory, and would also appear to be due to several causes, viz., irregular exposure of the pipe, lack of homogeneity of the metal, and water-line action.

TABLE 1.

Laboratory No. ... ..	2067.	2068.	2069.	2070.	2071.
Locality, miles and chains	2-52 from Weir.	4-61, Clackline.	4-62, Clackline.	4-72, Clackline.	6-36, Clackline.
Condition of Pipe ... ..	Bad.	Bad.	Very bad.	Bad.	Fair.
Calcium carbonate ... ..	·015	·008	·007	·005	·008
Magnesium " ... ..	...	·009	·002	·004	...
Sodium " ... ..	...	·055	...	...	...
Calcium sulphate ... ..	·005	...	...	...	·008
Magnesium sulphate ... ..	·018	...	·008	·004	·027
Sodium " ... ..	·023	·011	·083	...	...
Sodium nitrate ... ..	...	...	...	...	·001
Calcium chloride ... ..	...	...	...	...	...
Magnesium chloride ... ..	...	...	...	·007	·008
Sodium chloride ... ..	·015	·020	·100	...	·449
Iron Oxide and Alumina ... ..	·001	·008	·015	·008	·008
Silica ... ..	·018	·023	·008	·011	·015
Total ... ..	·096	·125	·088	·057	·544
Nature of soil ... ..	Dark grey sandy clay.	Greenish mica with clay & sand.	Dark grey sandy clay.	Dark brown clay and sand.	Grey sandy clay.

Laboratory No. ... ..	2095.	2127.	2128.	2129.	2130.
Locality, miles and chains	19° 60' Werribee.	Bed, North side, Avon River.	Northam office yard.	Seabrook Rail Mile, 83° 0.	Mandar, 92° 60.
Condition of Pipe ... ..	Bad.	Good.	Bad.	Fair.	Good.
Calcium carbonate ... ..	·008	·005	·008	·009	·009
Magnesium carbonate ... ..	·006	·001	·014	·012	·013
Sodium ... ..	...	...	·012	·067	·018
Calcium sulphate ... ..	...	...	...	...	...
Magnesium sulphate ... ..	·010	·013	...	...	...
Sodium sulphate ... ..	...	·003	·014	·010	·016
Sodium nitrate ... ..	...	...	minute trace.	minute trace.	minute trace.
Calcium chloride ... ..	...	...	...	...	...
Magnesium chloride ... ..	·001	...	...	...	...
Sodium ... ..	·017	·016	·086	·082	·042
Iron Oxide and Alumina ... ..	·020	·005	·004	·009	·006
Silica ... ..	·075	·012	·016	·019	·014
Total ... ..	·134	·055	·104	·163	·118
Nature of soil ... ..	Brown grey sandy clay.	Light brown sandy clay.	Grey clay.	Light brown clay.	Grey sandy clay.

Laboratory No. ... ..	2131.	2151.	2152.	2153.	2154.
Locality, miles, and chains	Meckering, 100° 60.	Wyola, 123° 68.	Wyola, 122° 71.	Wyola, 123° 57.	Wyola, 124° 40.
Condition of pipe ... ..	Fair.	Good.	Fair.	Fair.	Fair.
Calcium carbonate ... ..	·007	·017	·007	·007	·011
Magnesium carbonate ... ..	·013	...	·005	...	...
Sodium ... ..	·010	...	...	...	...
Calcium sulphate ... ..	...	·008	...	·080	·009
Magnesium sulphate ... ..	...	·063	·006	·245	·006
Sodium ... ..	·017	·084	...	...	...
Sodium nitrate ... ..	...	...	...	·001	minute trace
Calcium chloride ... ..	...	...	...	...	...
Magnesium chloride ... ..	...	...	·002	·065	·004
Sodium ... ..	·068	·415	·029	3·050	·319
Iron oxide and alumina ... ..	·005	·013	·010	·156	·014
Silica ... ..	·021	·084	·160	·057	·044
Total ... ..	·110	·608	·219	3·631	·409
Nature of soil ... ..	Grey clay.	Grey sand, little clay.	Grey sand, little clay.	Grey sand.	Buff clayey sand.

Laboratory No. ... ..	2181.	2182.	2183.	2194.	2195.
Locality, miles, and chains	Wyola, 124° 60.	Bungalla, 126° 11.	Bungalla, 126° 60.	Bungalla, 127° 3.	Bungalla, 140° 23.
Condition of pipe ... ..	Very bad.	Good.	Fair.	Very bad.	Very bad.
Calcium carbonate ... ..	·008	·004	·011	·006	·009
Magnesium carbonate ... ..	...	...	·014	·013	·013
Sodium ... ..	...	...	·027	·012	...
Calcium sulphate ... ..	·001	·018	...	...	...
Magnesium sulphate ... ..	·019	...	...	...	·006
Sodium ... ..	...	...	·020	·026	·015
Sodium nitrate ... ..	...	...	...	...	...
Calcium chloride ... ..	...	·006	...	...	...
Magnesium chloride ... ..	...	·012	...	...	...
Sodium ... ..	·123	·001	·053	·067	·060
Iron, oxide, and alumina ... ..	·016	·006	·042	·028	·017
Silica ... ..	·069	·081	·296	·133	·156
Total ... ..	·265	·078	·438	·305	·296
Nature of soil ... ..	Grey clayey sand.	Pink sandy clay.	Grey sandy clay.	Grey clayey sand.	White sandy clay.

Laboratory No. ... ..	2196.	2197.	2240.	2241.	2242.
Locality, miles, and chains	Bungalla, 141.70.	Keller- berrin, 143.75.	Keller- berrin, 152.40.	Doodle- kine, 154.40.	Doodle- kine, 155.33.
Condition of pipe ... ..	Bad.	Good.	Bad.	Fair.	Bad.
Calcium carbonate ... ..	.011	.011	.009	.028	.017
Magnesium carbonate ... ..	.012	.011	.009	...	.017
Sodium ... ..	.027	.043	.061	...	.012
Calcium sulphate ... ..	...	...	...	...	...
Magnesium sulphate ... ..	...	...	...	.081	...
Sodium sulphate ... ..	.046	.012	.084	...	.028
Sodium nitrate ... ..	...	...	.028	.019	.007
Calcium chloride ... ..	...	...	...	...	...
Magnesium chloride ... ..	...	...	...	...	...
Sodium ... ..	.223	.040	.053	.142	.102
Iron oxide and alumina ... ..	.003	.023	.031	.007	.015
Silica ... ..	.036	.118	.080	.081	.083
Total ... ..	.356	.258	.315	.238	.281
Nature of soil ... ..	Grey clayey sand.	Grey clayey sand.	Brownish grey sandy clay.	Buff sandy clay.	Grey clay.

Laboratory No. ... ..	2243.	2284.	2617.	2339.
Locality, miles, and chains ... ..	Hine's Hill, 167.53.	373.7 Soil in contact with incrustation.	326 Soil in contact with 2016.	361.70 Soil in contact with 2017.
Condition of pipe ... ..	Very bad.	Bad ?	Bad ?	Bad ?
Calcium carbonate ... ..	.029	.016	.017	.024
Magnesium carbonate ... ..	.015	.016	...	...
Sodium ... ..	...	...	.033	.057
Calcium sulphate ... ..	...	...	...	.079
Magnesium sulphate ... ..	.017	.008	...	.561
Sodium ... ..	.138	.092	...	...
Sodium nitrate ... ..	.089	...	...	...
Calcium chloride ... ..	...	...	.012	...
Magnesium chloride ... ..	...	...	.051	...
Sodium ... ..	.356	.083	.126	.222
Iron oxide and alumina ... ..	.013	.009	.020	.014
Silica ... ..	.018	.008	.013	.018
Total ... ..	.625	.227	.272	.966
Nature of soil ... ..	Buff sandy clay.	Bright red clay.	Buff clay.	Brownish red clay.

*Composition of External Incrustation.*—A typical sample of incrustation from the pipe in contact with soil No. 2284 of Table 1 was analysed with the following results :—

	per cent.
Iron peroxide, $\text{Fe}_2\text{O}_3$ ... ..	36.96
Iron protoxide, $\text{FeO}$ ... ..	6.44
Lime, $\text{CaO}$ ... ..	1.06
Magnesia, $\text{MgO}$ ... ..	.81
Water below $100^\circ$ ... ..	4.05
Water above $100^\circ$ ... ..	1.74
Carbonic anhydride, $\text{CO}_2$ ... ..	3.68
Sulphuric anhydride, $\text{SO}_3$ ... ..	.24
Chlorine, $\text{Cl}$ ... ..	.43
Insoluble clay, etc. ... ..	43.80

99.23



This is typical rust admixed with a good deal of soil. The presence of carbonates, sulphates, and chlorides shown by the analysis points to the influence of soluble salts in the formation of the incrustation.

Several other similar samples were examined and found to be identical with that analysed.

A qualitative analysis was also made of a sample of internal incrustation. This was of similar character, principally hydrated peroxide of iron with a little protoxide, carbonic acid, and mechanically held sand and organic matter.

*Relative Corrosion of Iron and Steel.*—Experiments have been made to determine the relative effect of the soils upon iron and steel, the idea being to determine, if possible, whether the steel at present in use was less suited for the purpose than iron or other steels. The metals tested were (1), Steel from present pipes ; (2), Mannesmann steel ; (3), soft iron. Bars of these metals were immersed in water extracts of the soils to such a depth that the area of metal exposed to the action of water was constant, viz., 27 sq. centimetres (4 3-16 sq. inches). Corrosion was apparent within a few hours after immersion, and after four days the amount of metallic iron removed from the bars in the form of rust was determined with the results in Table 2.

TABLE 2.

Extract from Soil No.	Pipe steel.	Mannesmann steel.	Iron.
	Milligrammes removed by corrosion.		
2182 ... ..	11.3	19.8	9.4
2195 ... ..	16.9	21.2	15.1
2196 ... ..	23.5	24.9	21.6
2241 ... ..	17.4	20.7	16.5
2243 ... ..	15.0	24.5	Lost
Mixed extracts of 10 soils ...	10.5	10.5	10.2

As was expected from its more homogeneous structure, the action on iron was slightly less throughout than that on either steel. However the inferior strength and increased cost probably more than counterbalances the slightly greater resistance to corrosion. Of the two steels experimented on, that in the present pipes is decidedly more resistant.

In connection with the corrosion of steel water pipes by salts in the soil, the following extract is of interest. It is taken from a Bulletin of the United States Geological Survey on reinforced concrete pipes.\*

Steel pipe is naturally limited to a thin shell on account of its great strength, weight, and cost. It is easily attacked by salts and acids, both on the inside by the water flowing through it and on the

\* Experiments on steel concrete pipes on a working scale by John Washington, 1905.

outside by the material surrounding it. A slight deterioration in so thin a shell means a large loss in strength, and the life of a steel pipe is therefore limited to a few years, depending upon the nature of the material in which it is laid. Experience has shown that in alkali ground in Southern California the life of a sheet-steel pipe is short. The life of the pipe may be lengthened by a coating, both inside and outside, of asphaltic material. The coating is applied by dipping the pipe into a hot bath of the asphalt mixture. If this dipping is not carefully done at just the proper temperature it is not likely to add much to the life of the pipe. The coating is liable to be broken in places by careless handling in transit from the factory to the work, and unless such places are recoated they are soon attacked, and the efficiency of the pipe is thus materially lessened. In all of the projects in the arid States more or less alkali ground is encountered, and in many of the projects provision has to be made for the drainage of the lands to get rid of the alkali. Under these circumstances other and more durable material than steel or iron must be sought.

*Prevention of Corrosion.*—Means were sought for preventing or at any rate checking the action of the salt of the soil on the pipe. Assuming, as stated in my previous report, that the cause of corrosion is the electrolysis of the dissolved salts with the consequent momentary liberation of substances of an acid character, reduction of corrosion should be brought about by the application to the soil, or to the surface of the pipe, of a substance which would either lower the conductivity of the salt solutions, or else immediately neutralise the liberated acid.

Substances of the former class appear mainly to be both expensive and difficult to apply practically. That they do materially reduce corrosion the following figures attest :—

	Corrosion with solution before addition of alcohol.	Corrosion after addition of alcohol.
Pipe steel ... ..	19.1	8.9
Mannesmann steel ...	14.6	7.0
Iron ... ..	16.0	9.4

Substances of the latter class must be alkaline, but not carbonated alkalis, these give rise to carbonic acid under the influence of electrolysis. Limestone was therefore expected to be valueless, and found by experiment to be so. Effective substances would be such oxides, hydrates, and basic silicates, as are readily attacked by acids. The following substances were actually tried and found effective :—

- (1.) Caustic soda.
- (2.) Caustic potash.
- (3.) Ammonia.
- (4.) Quick lime.
- (5.) Freshly slaked lime.
- (6.) Sodium silicate (water glass).

Portland cement was not tried, but would undoubtedly be equally effective.

The effect of all these substances was to indefinitely prevent corrosion, provided fresh supplies of air were not allowed to reach the soil solution with which the metal was in contact. Herein lies the bar to their practical application. Air contains sufficient carbonic acid to convert lime, etc., in process of time into the corresponding carbonates, and then all their protective influence is lost. The experiments with lime were therefore interesting, but disappointing. Two steel bars were partly immersed in 1 per cent. solution of sodium chloride and sodium sulphate. In one hour signs of corrosion were apparent, and rapidly increased. After two days, the iron removed by corrosion was 26.3 and 22.3 milligrams respectively. The corrosion was general, but slightly more marked near the surface of the solution. The experiment was then repeated with solutions of the same salts containing in addition  $\frac{1}{8}$  per cent. of lime. For four days no action whatever was noticeable, after that a very slow corrosion set in at the water line only, where the solution had become saturated with atmospheric carbonic acid. The action was allowed to proceed for 70 days, with the following results :—

The corrosion was confined to the surface level of the liquid.

The steel was corroded to a maximum depth of  $1\frac{1}{2}$  millimetres at this point.

The rust formed nodular incrustations, portions of which dropped off from time to time.

The rates of corrosion were 2.5 and 2.9 milligrams per day, as against 13.1 and 11.1 when no lime was used.

A similar experiment was made with the water extract of soil No. 2284, with the following results :—

	Corrosion after six days.	
	Without lime.	With lime.
Pipe steel ... ..	35.7	6.1
Mannesmann steel ...	38.1	10.3
Iron ... ..	44.2	3.3

The deductions to be drawn are that a thin layer of lime between the pipes and the soil would considerably retard corrosion at first, but that by absorption of carbonic acid from the air the protective effect would be gradually lessened until it became nil at the end of a very few years at most.

What may be called chemical methods of checking corrosion do not therefore appear to be practically successful. One is obliged

to fall back on the purely mechanical one of keeping the pipes sheltered from action by a strongly and closely adherent and impervious coating of some material having itself no effect upon the steel.

I have been unable to obtain details of the Barff process of treating pipes. It consists, I believe, of heating them in an atmosphere of steam until a thick and very adherent coating of magnetic oxide forms on the surface. This coating is said to be an excellent protection against rusting.

Time and experience have led to an almost universal belief in the tar-asphalt coating. It was lately stated in a technical journal that unless the carbolic acid be previously removed from the coal tar, such a coating has itself an action on the pipe, and tends to increase the loosening and flaking off which is the main objection to this coating. This is a point which should be noted if local tar is used. Mr. Reynoldson's own suggestion to use a jute binding with the tar-asphalt coat appears to be an excellent one. To avoid destruction in the hot asphaltic mixture the jute may require a previous soaking in a heavy oil, such as crude vaseline. Experiments on a working scale with this jute covering would be well justified, and at the same time as an alternative the toughening effect of the addition to the asphalt mixture of 10 or 15 per cent. of flake mica.

Graphite paint is largely used in the United States for the protection of metal work above ground with what are said to be excellent results. This, too, should be worth a working trial.

*Final Conclusions.*—The results of all the experiments made by myself, as well as the accounts of others made elsewhere, confirm me in the following opinions :—

1. Steel corrodes slowly when kept quite dry.
2. Steel rusts comparatively rapidly in contact with air and water.
3. The life of steel pipes is very considerably shortened when the soil in which they are laid contains over 0.1 per cent. of soluble salts, such as common salt, gypsum (calcium sulphate), etc.
4. They can only be preserved by a perfectly adherent and impermeable coating which itself has no action on the metal.
5. Such a perfect coating, owing to necessary rough handling, being impossible of attainment, the nearest possible approach to it should be secured.
6. In view of the necessary imperfections of the coating, the strongest efforts should be made to keep the soil in contact with pipes absolutely dry by drainage, diversion of surface water, checking leaks, substituting sand for clay as a covering, etc.

7. Iron is somewhat more resistant to corrosion than steel, and occasionally it may be more economical to use it in place of steel for pipes. In each case the relations between costs and efficiency must be carefully worked out.

EDWARD S. SIMPSON, B.E., F.C.S.,  
Mineralogist and Assayer.

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*Note.*—Researches into the causes of the corrosion of the pipes on the Goldfields Water Supply main were made in the Survey Laboratory during the year 1906. To assist in these investigations it was found necessary to enlist the services of Dr. F. S. Earp for a period of six months ; his salary, however, was paid by the Goldfields Water Supply Administration, in whose interest the special work was carried out. The information obtained as a result of the laboratory investigations of the soils from the Goldfields Water Supply pipe track, and their effect upon pipe steel and iron, are of considerable interest, and of more than mere local importance.

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